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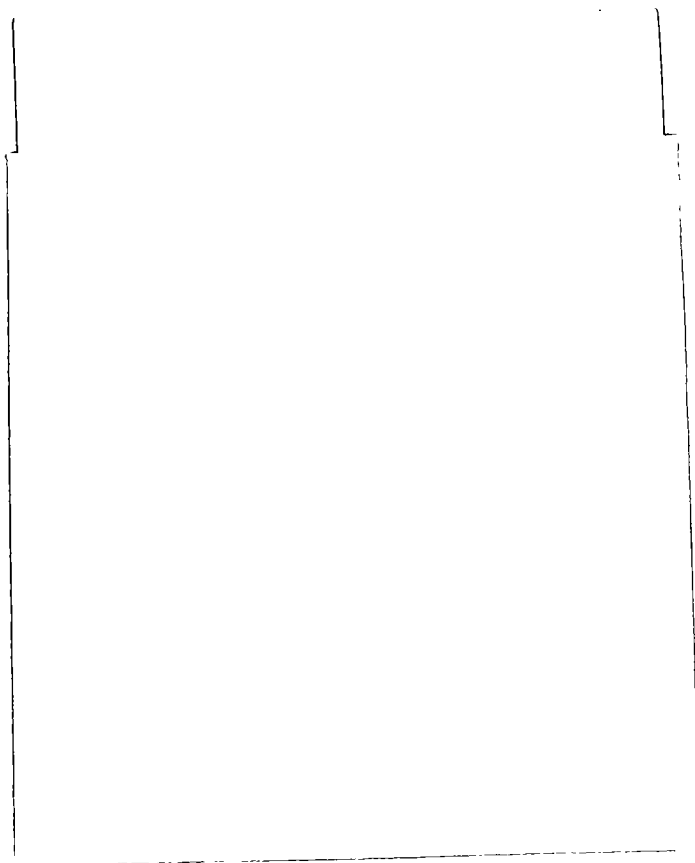
ARTILLERY SOUND RANGING AND FLASH RANGING



HEADQUARTERS, DEPARTMENT OF THE ARMY

OCTOBER 1964

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FIELD MANUAL
No. 6-122

HEADQUARTERS
DEPARTMENT OF THE ARMY
WASHINGTON, D.C., 19 October 1964

ARTILLERY SOUND RANGING AND FLASH RANGING

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*This manual supersedes FM 6-122, 12 June 1957.

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CHAPTER 2

SOUND WAVES AND THEIR PROPAGATION IN THE ATMOSPHERE

Section I. GENERAL

6. General

A disturbance produced by a local distortion of a continuous elastic medium is propagated in all directions from its source at a rate which depends on the physical properties of the medium and not on any characteristic of the source. The propagated wave may or may not be audible; that is, it may or may not be a sound wave, depending on the characteristics of the source and not on the properties of the medium. Waves of this type may be propagated through elastic solids, liquids, or gases. Artillery sound ranging depends on the measurement of the times of arrival of sound waves propagated through the atmosphere under whatever conditions happen to exist at the time.

7. Generation of Sound Waves

a. Impulse Wave. When a weapon is fired or a shell bursts, a region of intense pressure (an impulse wave) is produced. The surrounding air is displaced outward in all directions against air farther away from the point of explosion (*compression*). Because of the inertia of the moving air, the outward flow continues until the pressure at the point of explosion has been decreased to a value considerably below normal (*rarefaction*). The air then flows back into the low pressure area until the pressure returns to normal or sometimes to a value slightly higher and then back to normal. There is no continuous outward flow of air, but there is a continuous outward flow of energy, propagated by successive compression and rarefac-

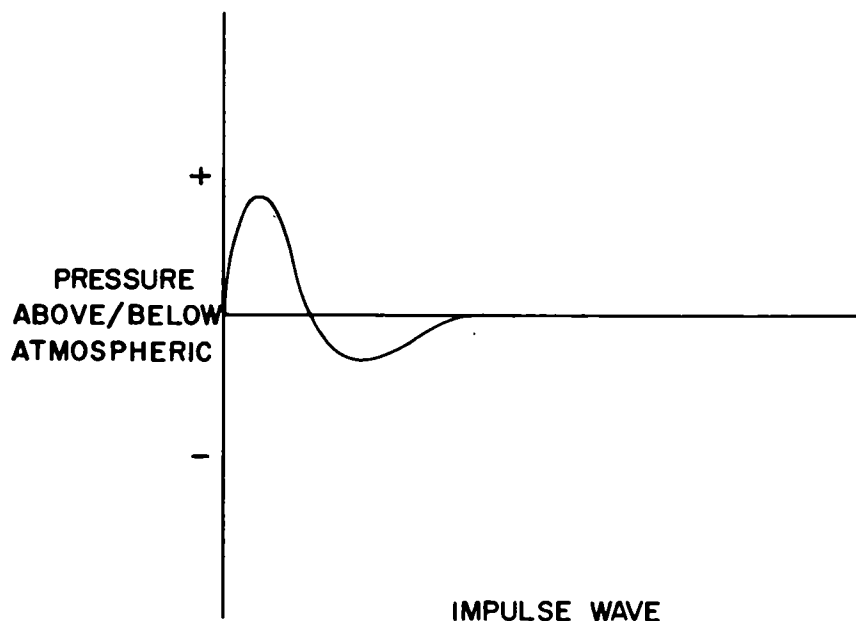


Figure 2. Impulse wave.

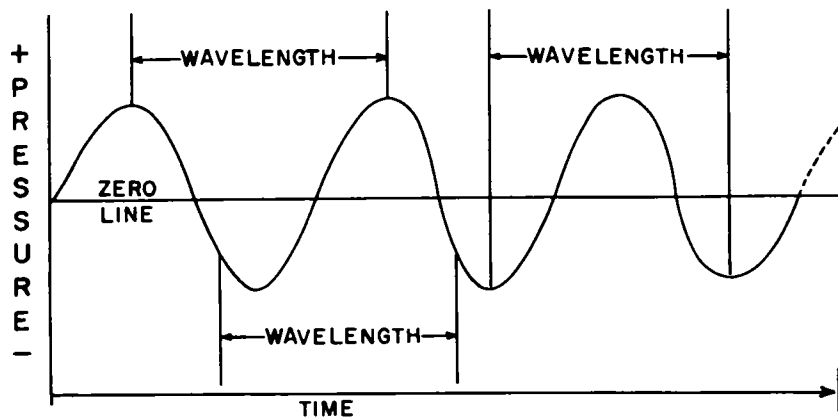
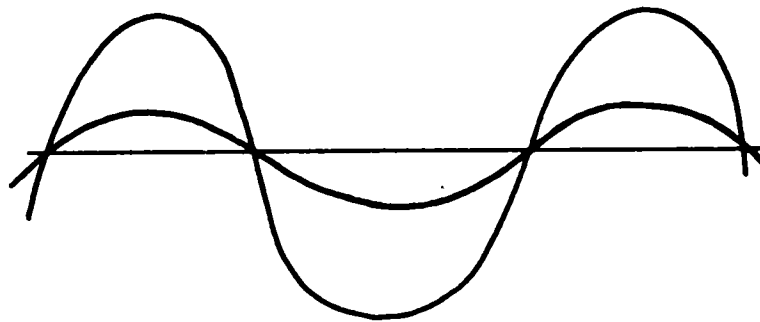
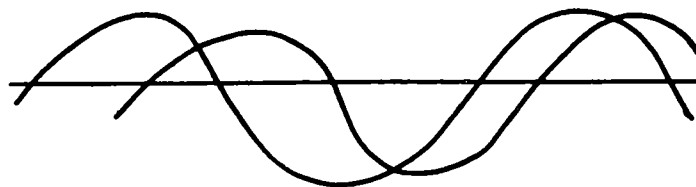


Figure 3. Continuous wave.



① In-phase oscillations



② Out-of-phase oscillations

Figure 4. Phase of oscillations.

tion of air in the neighborhood of each point along any path of sound. The process of compression followed by rarefaction is known as oscillation. A curve representing the variation of pressure with time at a given point on a path of the sound wave is shown in figure 2. This process is very similar to that which takes place

when a pebble is tossed into a quiet pool of water. As the pebble begins to sink, the water is raised upward and outward; it seeks to return to its undisturbed position by displacing water farther away, and a crest moves outward. Because of inertia, the initial motion of the water produces a trough which follows the crest

in its outward motion. Successive crests and troughs are propagated in circles of uniformly increasing radii until the oscillations at the point of origin are damped out (gradually decrease in amplitude until dissipated).

b. Continuous Wave. A continuous wave, which is a sound wave from a continuously vibrating source, is similar to the impulse wave discussed in *a* above except that it is not damped out. A wave of this type is represented in figure 3.

8. Characteristics of Sound Waves

a. Amplitude. The amplitude of oscillation of the sound wave is its maximum variation from the mean atmospheric pressure (zero) line on the curve shown in figure 3.

b. Frequency. The frequency of oscillation of a sound wave is the number of oscillations

completed in a time unit. Its reciprocal, the *period*, is the time required for one complete oscillation (cycle); that is, the time required for the pressure to increase from the mean, or zero, to the maximum, decrease to minimum, and return to the mean. The range of audible frequencies is approximately 20 cps (cycles per seconds) to 20,000 cps. Some individuals can hear sounds of lower or higher frequencies.

c. Phase. Two oscillations of a sound wave are said to be in phase when corresponding parts of both oscillations occur simultaneously (1, fig. 4). Two oscillations are said to be out of phase when corresponding parts occur at different times (2, fig. 4).

d. Wavelength. The wavelength of a sound wave is the *shortest* distance along the line of propagation between two oscillations at the same point in the same phase (fig. 3).

Section II. SOUND PROPAGATION

9. Sound Paths

a. If temperature and humidity were constant and uniform throughout the atmosphere and if there were no winds or air currents, the speed of propagation of sound through the atmosphere would be the same in all directions.

b. Under the conditions given, the propagated sound wave fronts are spheres of uniformly increasing radii. The path of any given point on a wave front as it moves away from the source is a sound path (or sound ray). In this case, the sound rays are straight lines, the radii of the spherical wave fronts.

10. Variation of Velocity of Sound

a. Since the ideal conditions of wind, temperature, and humidity stated in paragraph 9*a* are seldom encountered, the velocity of sound will usually vary throughout different portions of the atmosphere.

b. In general, if the combined effect of weather elements is such that the velocity of sound is less at the surface of the earth than it is at higher elevations, then the upper portions of a wave front will move ahead of the

lower portions, and rays will be deflected (*refracted*) downward. This condition, as illustrated in figure 5, is the one most favorable for sound reception. It may result from one or more of the following causes:

- (1) Temperature increases as height increases.
- (2) Wind and sound are moving in the same direction, and wind velocity increases as height increases.
- (3) Wind and sound are moving in opposite directions, and wind velocity decreases as height increases.

c. If the condition in *b* above is reversed, the lower portions of a wave front will move ahead of the higher ones; then the sound will be refracted upward. This condition, as illustrated in figure 6, makes sound ranging difficult or even impossible. This condition may result from one or more of the following causes:

- (1) Temperature decreases as height increases.
- (2) Wind and sound are moving in the same direction, and wind velocity decreases as height increases.

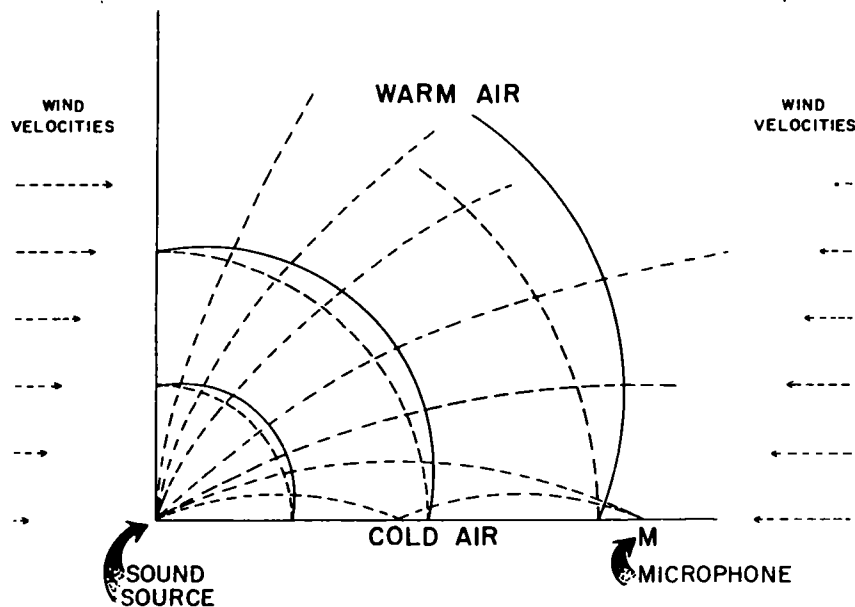


Figure 5. Influence of temperature and wind variations on propagation of sound waves (waves refracted downward).

- (3) Wind and sound are moving in opposite directions, and wind velocity increases as height increases.

11. Other Effects in Propagation of Sound

a. Reflection. Sound waves are reflected from any large surface, such as the side of a large building, cliff, or mountain; thus, microphones located to the front of such an object may receive confusing echoes.

b. Interference. Two sound waves from the same source may cause interference if they are traveling by different paths to the same point. If the two waves are in phase, one wave will reinforce the other and the resulting sound will be of greater intensity (amplitude) than either of its components. If the two sound waves are out of phase, one wave will tend to cancel out the other; under extreme conditions, a combination of two such sound waves may result in silence.

c. Diffraction. If relatively small terrain features, such as buildings or small hills, are in the path of a sound wave, the sound wave will be propagated around the subject. A sound wave which arrives at a microphone behind a

mask will have traveled around the mask; consequently, its travel time is longer than that of a wave which travels in a straight line from the source to the microphone. Behind such masks, regions of low intensity, or "sound shadows," may be produced. Microphones located in regions of sound shadows will be relatively insensitive.

d. Attenuation. Independently of other effects, the distances at which sound ranging is possible are limited by the attenuation (energy loss) of the sound wave as it is propagated outward from the source. This attenuation results from two causes—first, since the total energy flowing outward is uniformly distributed over the surface of a spherical wave front, the intensity of sound at any point varies inversely to the square of its distance from the sound source; and second, energy is absorbed by the medium through which the sound is propagated (the atmosphere).

e. Air Currents and Turbulence. Turbulent motion in the atmosphere and vertical air currents may occur. These conditions may exist to some degree even in seemingly calm and settled weather. Since there is no method of

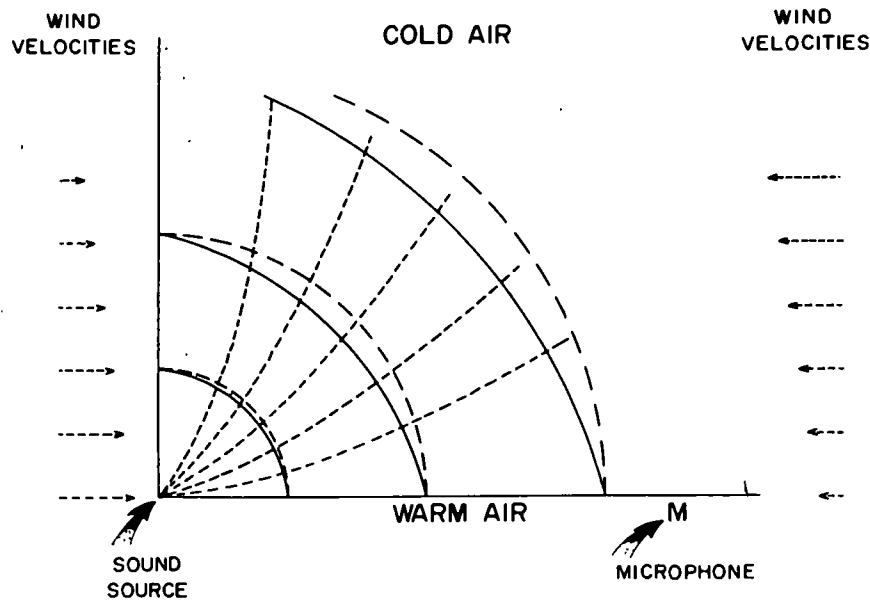


Figure 6. Influence of temperature and wind variations on propagation of sound waves (waves refracted upward).

applying corrections for such phenomena, they may have an adverse effect on the accuracy of sound ranging locations. During periods of unsettled weather, conditions become less favorable for sound ranging. Under extreme conditions, standard weather corrections may have no meaning and the use of sound ranging to adjust fire may not be sufficiently accurate to merit firing.

f. Terrain. In addition to the effects of terrain mentioned in *c* above, it may be expected that irregular terrain and dense forest may cause variation in sound velocity along various paths, thereby causing an adverse effect on accuracy of sound ranging. At present, effects of terrain are not well understood and means of correcting these effects are not known.

Section III. ARTILLERY SOUND WAVES

12. General

There are several distinct sounds associated with artillery fire, some or all of which may be produced when a single round is fired. Only two of these, the gun wave and shellburst wave, are of general use in sound ranging; a third, the ballistic wave, may have occasional use (ch. 15).

13. Gun Wave

The gun wave, or muzzle wave, is the sound produced by the piece when it is fired. Gases under high pressure suddenly released from the muzzle create a pressure wave which is propa-

gated as described in paragraph 6. The shape of the wave front becomes very nearly spherical after the sound has traveled a short distance; the center of curvature is a few meters ahead of the muzzle. This sound wave has the lowest frequency of all gunfire sound waves; it is further characterized by great amplitude (greatest of all waves at distances greater than 5,000 meters). The waveform is smooth and, in general, the larger the gun, the longer is the period of oscillation (para. 8).

14. Shellburst Wave

The shellburst wave, or detonation wave, is an impulse wave which originates from the

bursting of a high explosive shell. It is similar in some respects to the gun wave but results from a violent detonation rather than from the explosion of a slow-burning propellant charge. The energy of the detonation is distributed over a wide range of frequencies. At short distances, a shellburst wave has high frequency waveforms; at long distances, its frequency is almost identical with that of a gun wave.

15. Ballistic Wave

a. A projectile with a velocity in flight greater than the velocity of sound creates a ballistic wave in the same manner as the bow of a ship cutting through water creates a bow wave. The presence of a ballistic wave is apparent to an observer near the line of flight of the projectile because two distinct sounds are heard. The first, a sharp crack, is the ballistic wave. The second, a lower pitched boom, is the gun wave. The ballistic wave is of higher frequency

than either the gun wave or the shellburst wave. Although at comparable distances the ballistic wave is of lower amplitude than either the gun wave or the shellburst wave, it may, because of its proximity to the microphone base, be recorded as a higher amplitude wave than either the gun wave or shellburst wave.

b. Another type of ballistic wave, sometimes observed when a shellburst occurs near the microphone base, is the splinter wave. This is a ballistic wave of low amplitude, produced by shell fragments or splinters moving faster than the speed of sound.

16. Whistling

A whistling, rustling, or hissing sound associated with the shell in its flight is caused by interference of sound (pressure) waves within the shell wave cone. This whistling sound is of high frequency and is not considered in sound ranging.

CHAPTER 3

THEORY OF SOUND RANGING

17. General

The discharge of a gun or the burst of a shell causes a sound disturbance or pressure vibration of the air which lasts for only a fraction of a second. The impulse so produced, a sound wave travels outward through the air at speeds which are dependent on atmospheric conditions. Sound ranging techniques are used to locate the source of the sound wave, the gun or the shell, by measuring the relative times of arrival of the sound wave at several accurately located microphones.

18. Basic Theory

In figure 7, two microphone positions, A and B, are shown. As the sound wave passes over A, the arrival time is recorded; as the sound wave moves on, it passes over B, and this arrival time is recorded. By subtracting the arrival time at A from the arrival time at B, the time interval (time taken for the sound wave to travel from A to B) can be determined. The time interval so determined when multiplied by the velocity of sound may be considered as one side of the right triangle (A'-B), the other two sides being the line between the microphones (A-B) and the chord of the sound wave front (A-A') at the time it passed over microphone A. The value of angle θ can then be computed by use of the trigonometric formula in $\theta = T/S$, where T equals the time interval multiplied by the velocity of sound and S equals the length of the line A-B. If the value determined for angle θ is then laid off from the perpendicular bisector of the line A-B, by using the point of bisection as a vertex, in the direction toward the microphone over which the sound wave first passed, a line running through, or very near, the sound source will be produced. If several such lines are produced from several pairs of microphones, the intersections of these lines, or rays, will result in a location of the sound source.

19. Plotting Correction

a. In figure 7, point A' on the wave front is not the same point on the wave front that passes over microphone B. The point which actually passes over microphone B is labeled B'. The distance B'-B is somewhat shorter than the distance A'-B. When the sound source is at a greater distance from the microphone base, the difference becomes negligible. When the sound source is at a short distance, the difference is a very real factor and must be taken into account.

b. The distance B-B' represents the measured time interval. This value must always be *increased* by a value called the curvature correction (curvature of the sound wave front) before the sound source location may be accurately plotted. The application of this correction is discussed in paragraph 87.

20. Weather Corrections

The speed at which the sound wave travels from microphone A to microphone B in figure 7 is dependent on atmospheric conditions at the time of travel. Standard atmospheric conditions for sound ranging are virtual temperature 50°F. and no wind. Deviations from these conditions can either increase or decrease the velocity of the sound wave. As a result of these deviations in standard atmospheric conditions, corrections are applied to the measured time interval to determine the corrected time interval. The resulting corrected time interval is called a weather-corrected time interval, and it is then used to compute the value of angle θ . The derivation and application of these corrections are discussed in paragraphs 83 through 86.

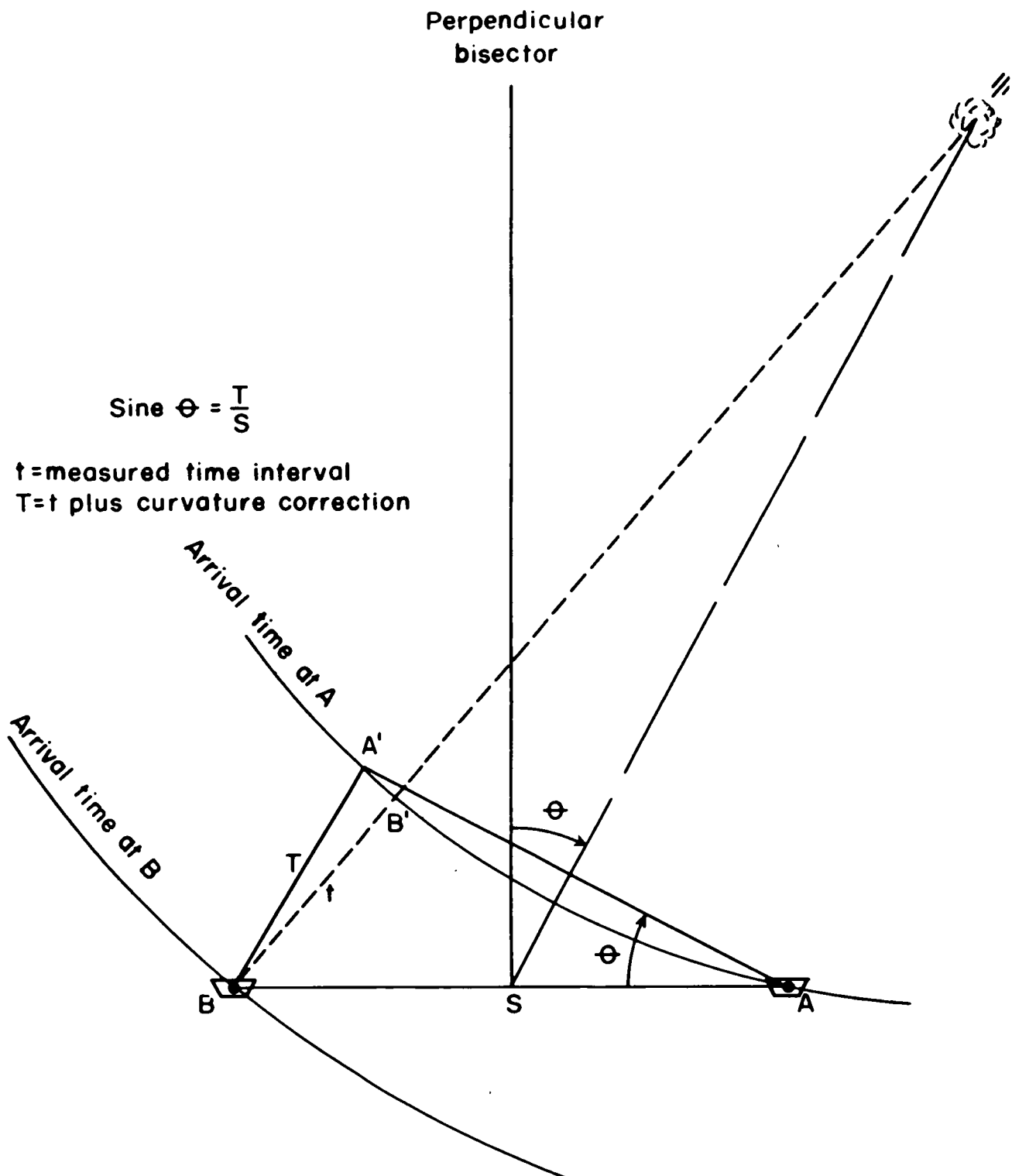


Figure 7. Time interval computations.

CHAPTER 4

TYPES OF SOUND RANGING BASES

21. General

a. Sound Ranging Base. Depending on the time available for the installation of the base and the terrain in the area of the base, a sound ranging base consists of from four to six microphones (fig. 8). A minimum of four microphones must be installed to permit at least a three-way intersection at the sound source. An increase in the number of microphones increases the number of intersecting rays and improves the reliability of the location of the sound source.

b. Subbase. The line, or distance, between any adjacent pair of microphones is called a subbase and is normally measured in sound seconds or meters (fig. 8). A *sound second* is the distance sound will travel in 1 second under standard atmospheric conditions (337.6 meters); therefore, a 2-second subbase is 675.2 meters in length, and a 4-second subbase is 1350.4 meters in length.

c. Numbering System. Microphones in a sound base are numbered consecutively from right to left facing the direction of ranging (fig. 8); they are designated by the symbols M_1 , M_2 , etc. The midpoints of the subbases (the point of bisection of the perpendicular bisector of the subbase) are numbered consecutively from right to left in the same manner as the microphones (fig. 8); they are designated by the symbols C_1 , C_2 , etc.

d. Azimuth Designation. The azimuth of a subbase is the direction from a lower numbered microphone to the next higher numbered microphone (fig. 8). The azimuth of a sound ranging base is the direction from the lowest numbered microphone to the highest numbered microphone of the base.

22. Types of Bases

There are two general types of sound ranging bases, regular and irregular.

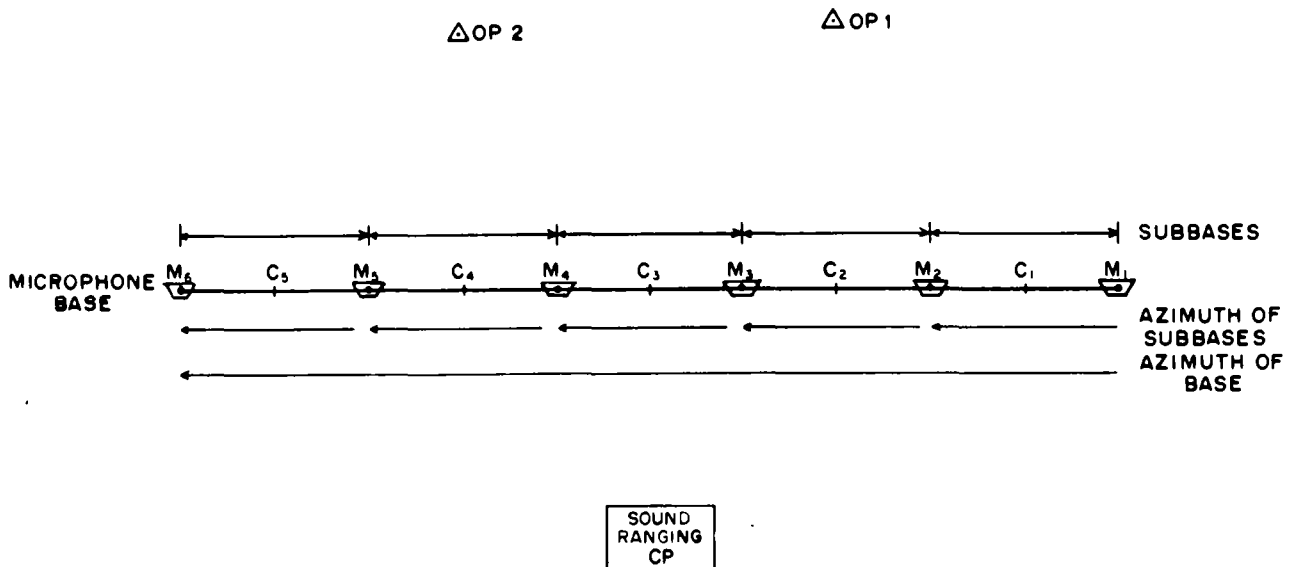


Figure 8. Elements of a sound base.

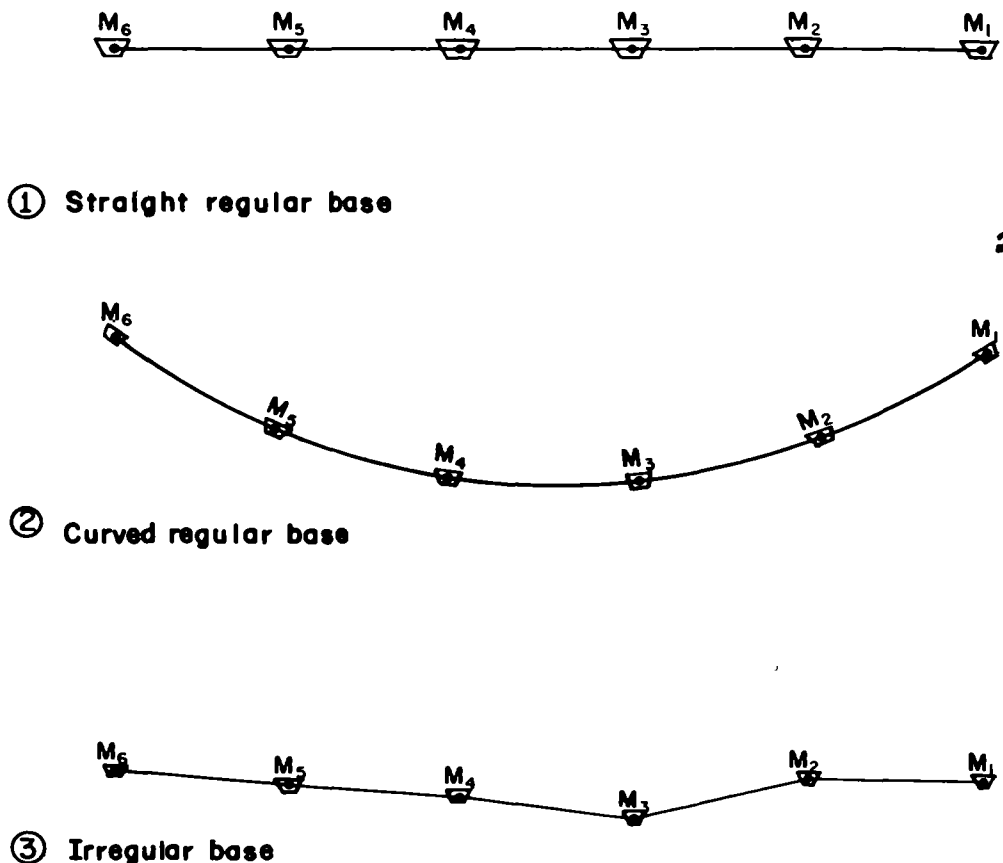


Figure 9. Types of sound bases.

a. Regular Bases. Regular sound ranging bases are those bases which have microphones positioned at uniform intervals (subbases) along a straight line (straight regular base) (1, fig. 9) or along the arc of a circle concave toward the direction of ranging (curved regular base) (2, fig. 9).

b. Irregular Bases. Irregular sound ranging bases are those bases which either have microphones positioned at irregular intervals (subbases) or microphones positioned in an irregular alinement or both (3, fig. 9).

23. Comparison of Types of Sound Ranging Bases

a. Regular Bases. The regular spacing of the microphones of regular sound ranging bases causes recordings of sound arrival times to form an easily recognized pattern for evaluation. Many of the plotting and correction charts and devices are manufactured for use with

regular sound ranging bases. Use of the curved regular base prevents the possibility of mirror plotting to the front of the base a sound which actually originated to the rear of the base. Terrain features in the area of operations may make it difficult to fit a regular base into the terrain and have the microphones located at acoustically favorable positions. Nonetheless, because of the advantage of the more easily evaluated recording of the sound arrival times, the regular base is the most frequently used type of installation. In practice, the most commonly used type is a straight regular base with a 1,200- to 1,400-meter spacing between adjacent microphones.

b. Irregular Bases. The irregular spacing of the microphones of irregular sound ranging bases causes irregularities in the pattern of sound arrival times with the result that the evaluation of the recordings may be difficult depending on the degree of irregularity. The

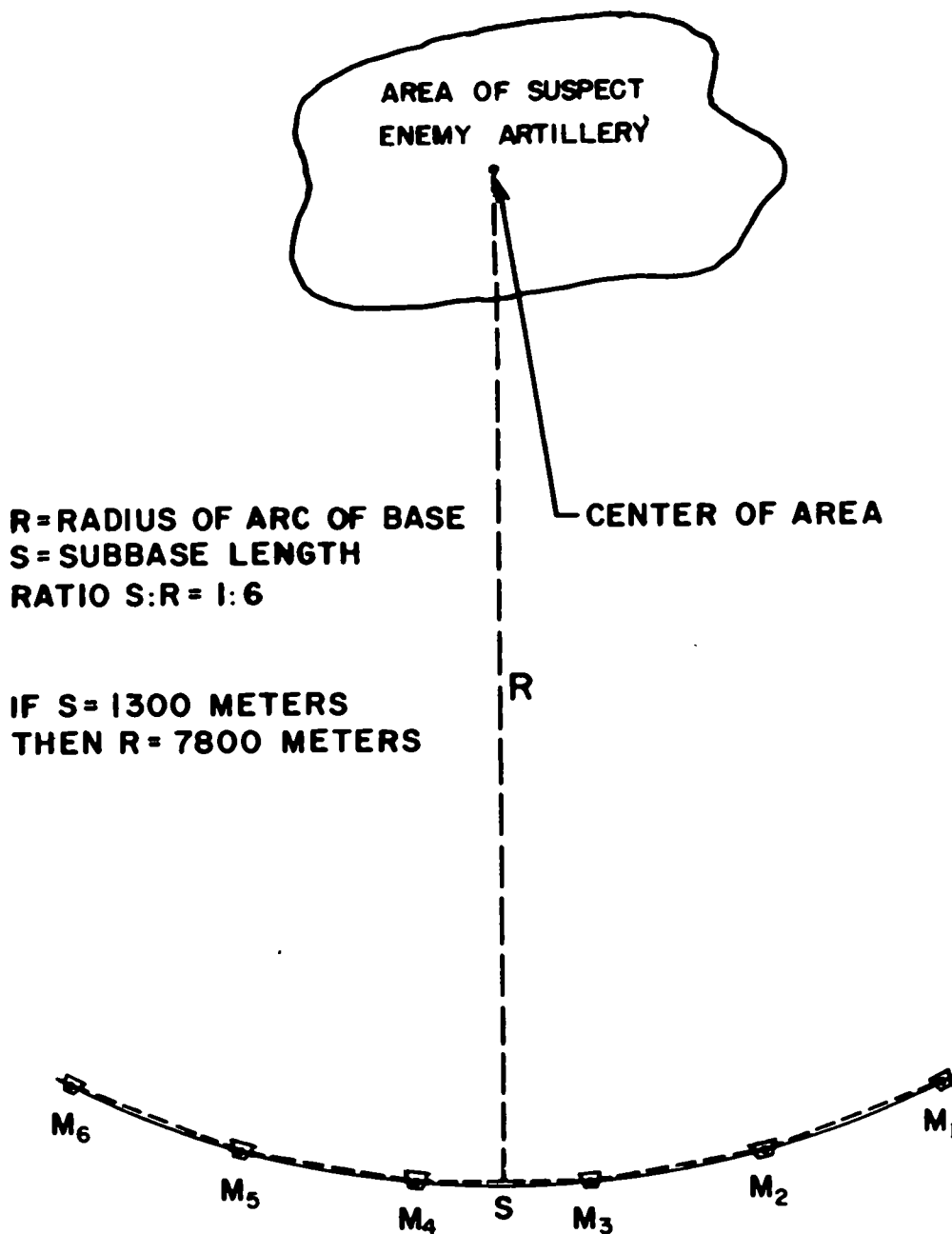


Figure 10. Radius of the curved regular base.

determination and application of time interval corrections for irregular bases will usually be slightly more complex than for regular bases. The microphones of the irregular base can be readily fitted into the terrain in the area of operations so that all microphones are located in acoustically favorable positions. In general, when an irregular base is installed, the microphones should be spaced as nearly equidistant

and as nearly on a straight line or uniform curve as the terrain permits. The irregular base will be used when the terrain is not suitable or time is not available for the installation of a regular base.

24. Radius of the Curved Regular Base

The radius of the arc on which a curved regular base is established is related to the

length of the subbase that is to be used and the distance from the midpoint of the base to the center of the area to be ranged on. The ratio of subbase length to the radius of the arc varies from 1:6 to 1:9. Figure 10 shows the relationship between the radius of the arc, the subbase

length, and the distance to the center of the area to be ranged on. A subbase length and a radius of the arc will be selected which will fit the base to the available terrain and place the center of curvature near the center of the area to be ranged on.

CHAPTER 5

SELECTION OF SOUND RANGING INSTALLATIONS

Section I. REQUIREMENTS FOR A SOUND RANGING INSTALLATION

25. Elements of a Sound Ranging Installation

A sound ranging installation is composed of three elements—sound ranging observation posts, a microphone base, and a sound ranging command post (fig. 8).

a. Observation Posts. To avoid excessive drain on the power source and waste of recording paper, the observers operate the equipment which records the arrival time of the sound of enemy weapons firing only when it is necessary to record. So that personnel can operate the equipment at the proper time, observation posts are positioned forward of the detecting equipment (microphones). The observers start the recording process when the sound of enemy weapons firing is detected.

b. Microphone Base. The microphones detect the sound of enemy weapons firing, convert this sound to an electrical impulse, and transmit this impulse to the recording equipment.

c. Command Post. The sound ranging command post houses the equipment for recording the impulses transmitted by the microphones of the sound ranging base and the devices and personnel necessary to evaluate these recordings for determining the location of the sound source.

26. Sound Ranging Observation Posts

Positions selected for sound ranging OP's should—

a. Be so located that the observer will hear a sound from any part of the target area at least 2 seconds before that sound arrives at any microphone on the base. This time lapse will

compensate for the delay in the observer's reaction time and the delay in the start of recording operations of the recording equipment.

b. Provide a vantage point for visual observation into enemy territory to aid in the estimation and distance of the sounds of enemy weapons firing.

c. Be as free as possible from any interfering noises, such as small-arms fire, friendly artillery fire, and vehicular traffic, which would mask the sound of enemy weapons firing.

d. Provide cover and concealment for the observers.

e. Offer a covered route of approach.

27. Microphone Base

The microphone base, if possible, should be—

a. Located as close as possible to friendly forward elements, consistent with proper location of the observation posts, in order that sound observation will be extended as deep as possible into enemy territory.

b. Positioned so that the perpendicular bisector of the base passes as closely as practicable through the center of the target area (fig. 11).

c. Positioned so that individual microphones will—

- (1) Be unaffected by excessive interference from undesirable sounds, such as heavy shelling, friendly artillery fire, or heavy vehicular traffic.
- (2) Be in the direct path of sound waves from enemy weapons and away from such terrain features as sharp cliffs, steep hills, or large buildings to avoid

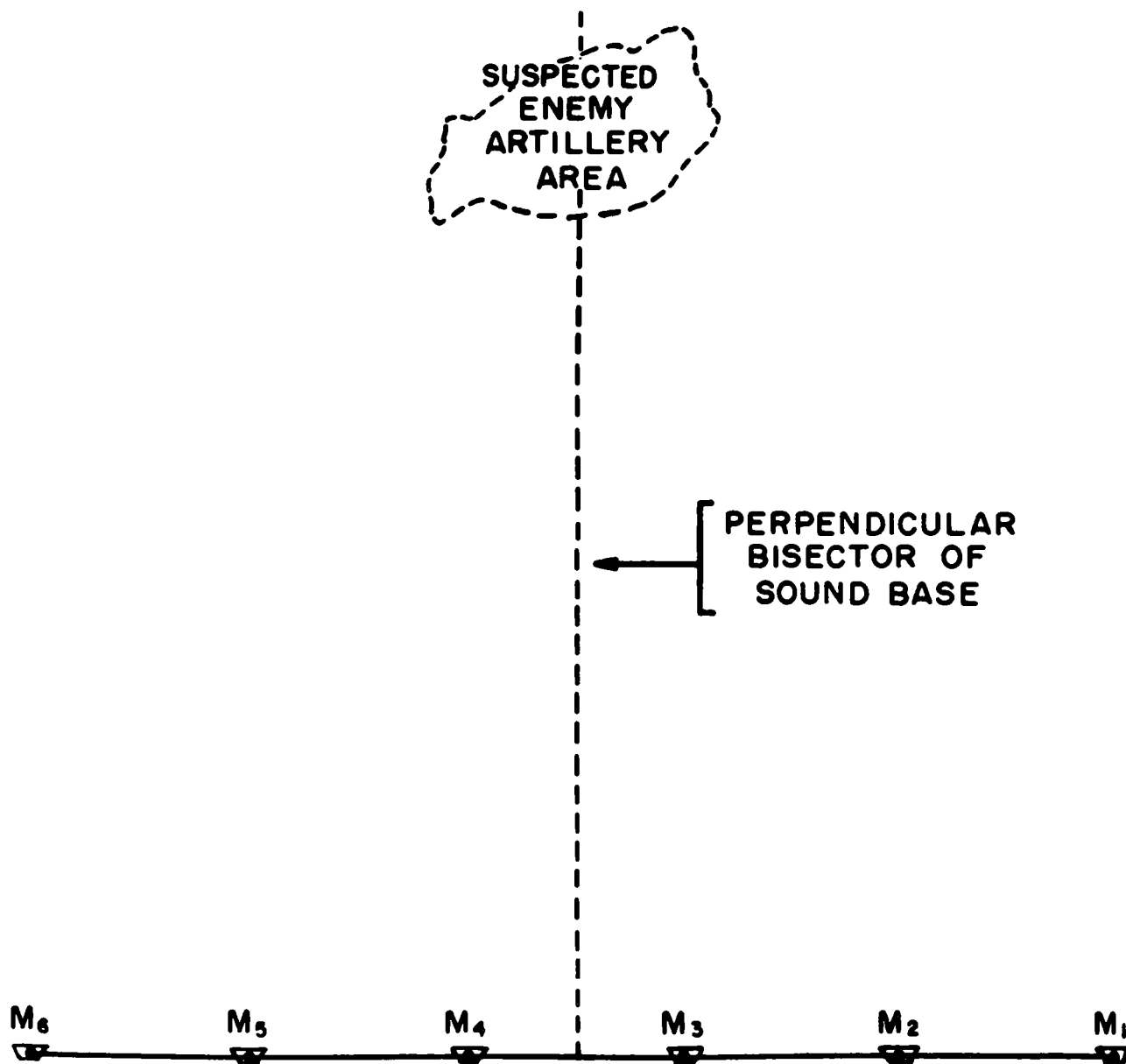


Figure 11. Location of sound base in relation to area of probable location of enemy artillery.

echoes, sound shadows, or multiple arrivals.

- (3) Be as near the same height as feasible not to exceed 200 feet difference in height between adjacent microphones.
- (4) Facilitate survey and communication operations.

a. Be as near the center of the microphone base as is consistent with security in order to reduce the communication requirements as much as possible.

b. Provide cover and concealment for the necessary equipment and personnel.

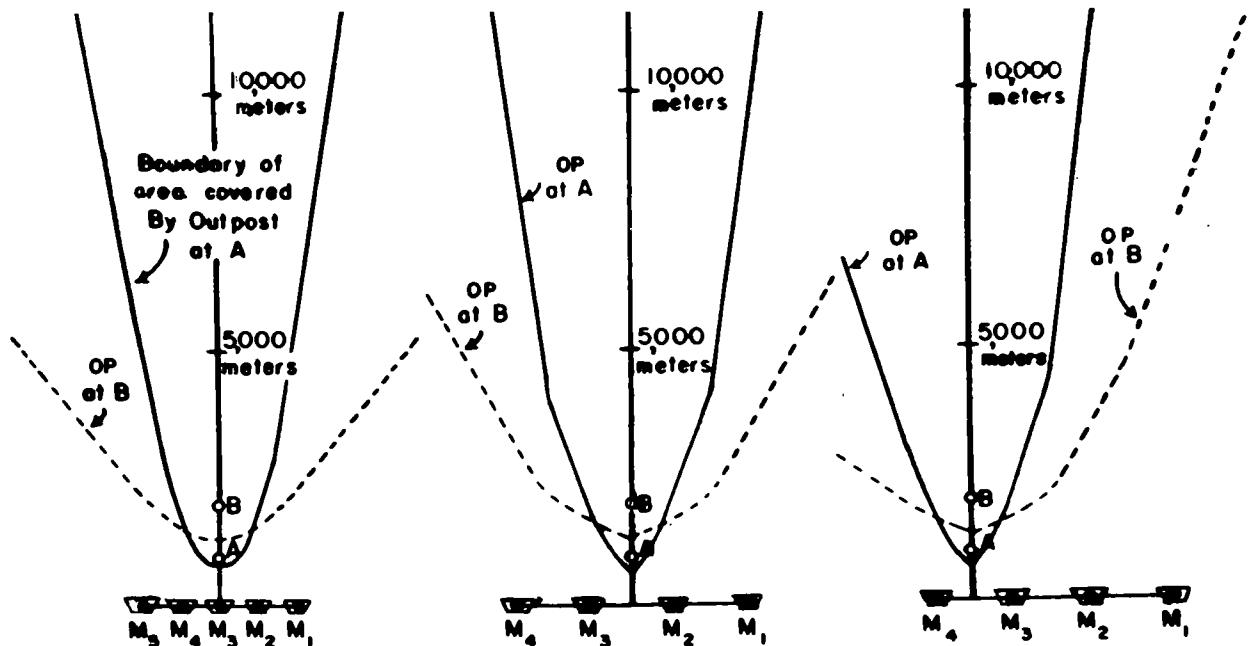
c. Offer a covered route of approach.

28. Sound Ranging Command Post

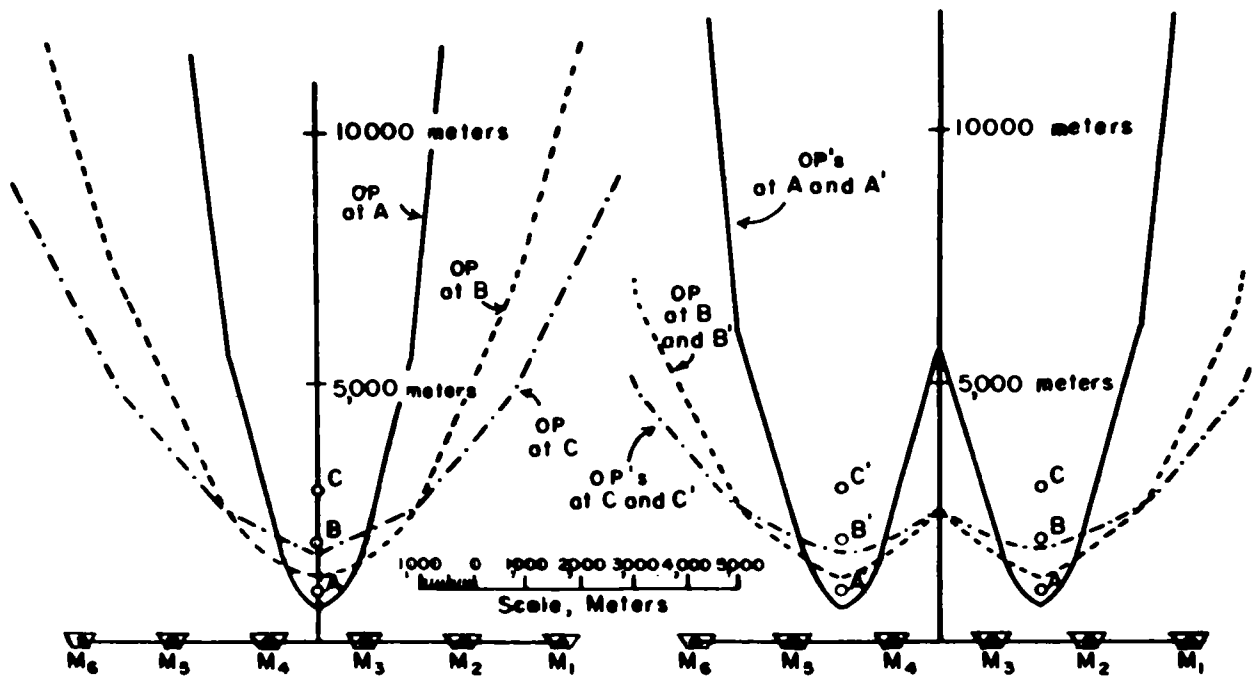
The location of the sound ranging command post should—

29. Position Selection Considerations

In addition to the requirements for the various elements listed in paragraphs 26 through



① 2-second 5-microphone base. ② 4-second 4-microphone base. ③ 4-second 4-microphone base.



④ 5-second 6-microphone base with one OP.

⑤ 5-second 6-microphone base with two OP's.

Figure 12. Area of target locations from which a sound is heard by the observer at least 2 seconds before it arrives at any microphone.

28, certain other basic considerations must be taken into account in selecting positions for sound ranging installations. These considerations include—

a. The correct lateral positioning of the observation posts with respect to the sound base. In most cases, two observation posts will be employed with each sound base, one forward

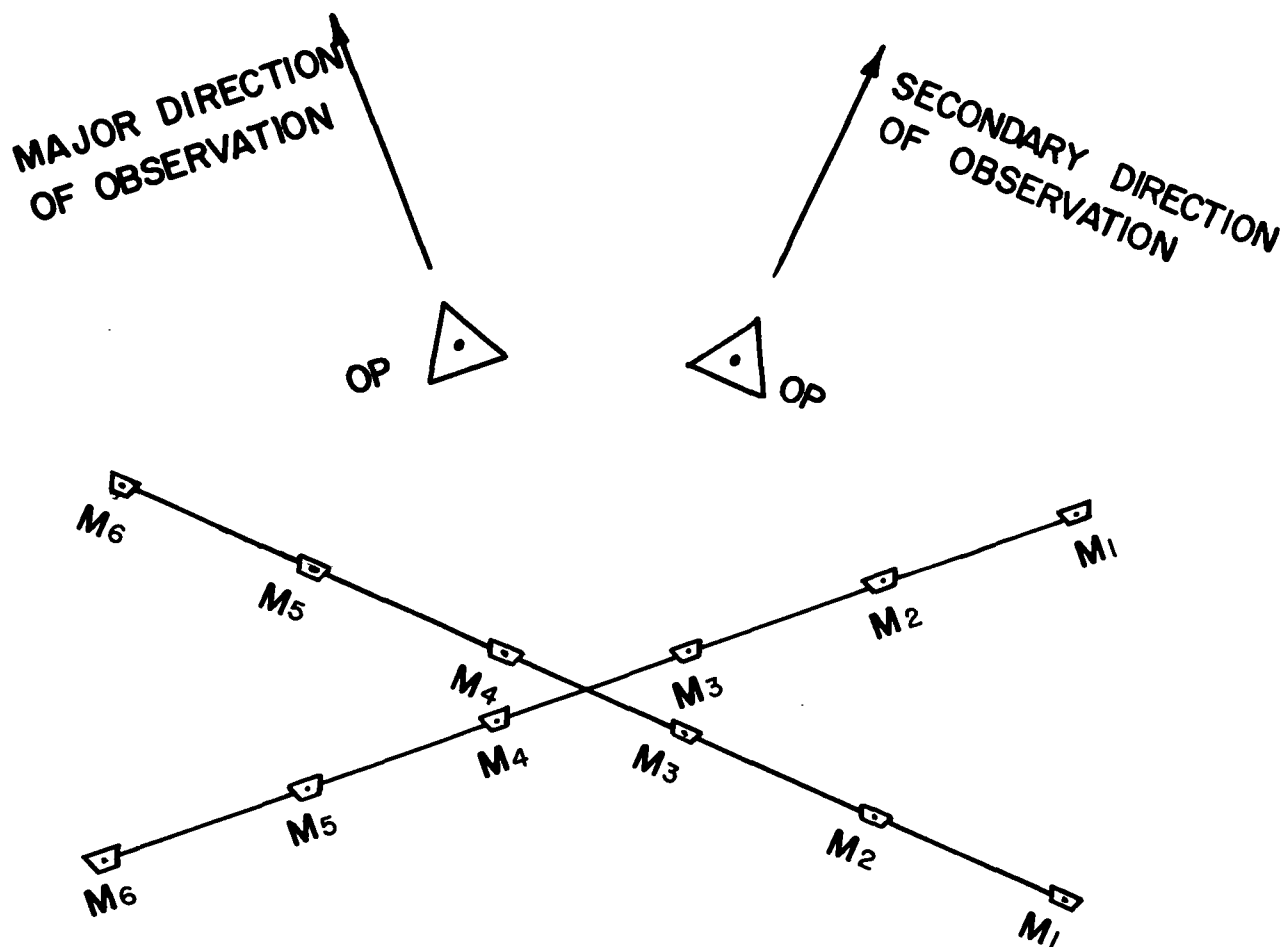


Figure 13. Crossed sound bases.

of microphone 2 and one forward of microphone 5. Also, the observation posts must be not so far in front of the microphone base that correlation or communication becomes a problem. Sound ranging coverages for various observation post positions are shown in figure 12.

b. The correct selection of the microphone positions, considering the size and type of sound base being used. The factors in (1) through (5) below will influence the selection of microphone positions:

- (1) If the time available for installation is limited, a base consisting of short subbases may be used. In these circumstances, an effective subbase length may be 600 to 700 meters. This length facilitates expansion into a longer subbase (1,200 to 1,400 meters) when time becomes available. It must be

remembered that the short subbase has a shorter range capability.

- (2) Rough terrain in the area available for positions may dictate the installation of an irregular base.
- (3) A limited target area may allow the use of a curved base, which, because of its special characteristics, produces more accurate locations.
- (4) An extensive target area may require the use of crossed bases for adequate coverage (fig. 13). (The use of switchboard SB-223 allows this operation to be carried out by the use of one sound recorder.)
- (5) A prevailing wind from one flank may require that the sound base be shifted downwind to compensate for the wind effect on the sound travel path.

Section II. RECONNAISSANCE

30. Map Reconnaissance

a. *General.* Reconnaissance is started as soon as orders for employment of the sound platoon have been received. In many cases, the map reconnaissance can be completed prior to the receipt of orders, particularly when units have been operating in a sector for a period of time and are able to plan for the occupation of future positions.

b. *Maps.* The scale of maps used in reconnaissance for a sound ranging installation is usually 1:50,000 with relief shown by contour lines. In addition to the proposed sound ranging installation, the position of the forward edge of the battle area and the target area which is to be covered should be shown on the map.

c. *Template.* A transparent template of appropriate scale, showing the relative location of microphones for the type of base to be used and the optimum positions for the observation posts, can be used on the map to determine the posi-

tions to be occupied (fig. 14). The template is superimposed on the map with the perpendicular bisector of the base centered on the target area. The template is then shifted about until the proper relationship to friendly frontlines is obtained, the observation posts are located on suitable terrain, and the microphones are in acoustically suitable positions. The grid references of observation posts and microphones are then determined on the map, and the command post is selected. These selected positions are not considered final until a ground reconnaissance has been completed.

d. *Routes of Approach.* The sound platoon commander should make a careful map study of the road net in order to select routes which will provide maximum concealment. Alternate routes should also be selected to insure ease of movement around areas subjected to enemy observation and enemy fire and around destroyed bridges, etc.

e. *Line Routes.* Tentative line routes should be selected from the map to aid in estimating

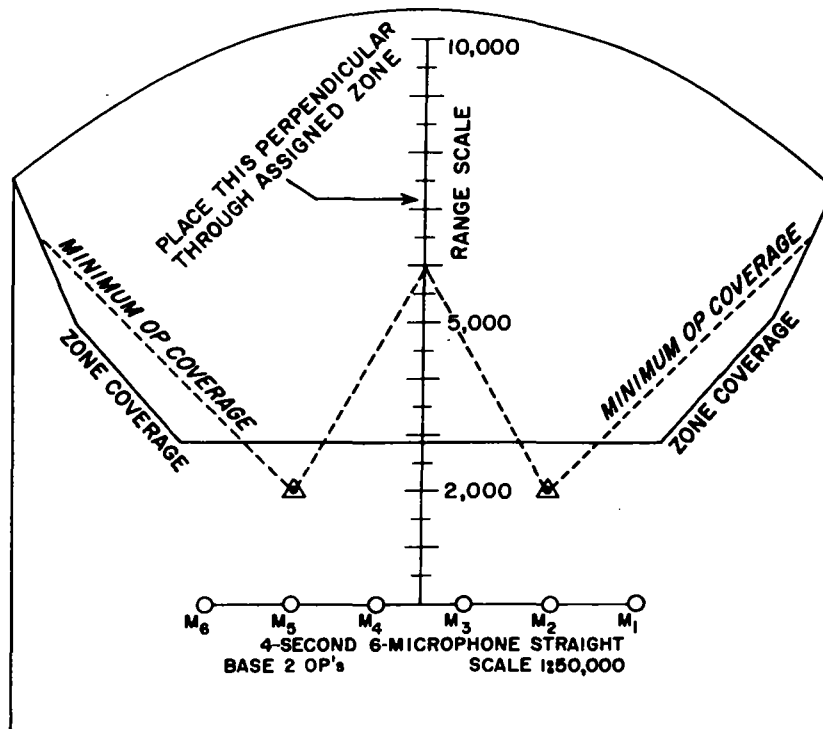


Figure 14. A typical sound ranging position template.

the approximate amount of cable needed to install the sound base.

f. Alternate Positions. It is important that alternate OP, CP, and microphone locations be selected from the map. This step will save much time in ground reconnaissance. Alternate positions should possess the same characteristics as primary positions.

g. Survey. After initial selection of positions from the map, the sound platoon commander should coordinate with the battery survey platoon commander. Survey control points from trig lists should be plotted on the map, or usable reference points should be plotted when trig lists are not available.

31. Ground Reconnaissance

a. General. The ground reconnaissance, prior to a displacement of the sound platoon, is begun as soon as the situation permits. The purpose of the ground reconnaissance is to verify, confirm, and/or improve the locations selected during the map reconnaissance.

b. Orienting the Ground Reconnaissance Party. Ground reconnaissance may be started from an occupied position or from a rendezvous area. Prior to leaving the rendezvous area, the sound platoon commander should inform the men in the party of key points along the route to be traveled. He should specify the area where any accompanying vehicles are to be left and an area where all personnel are to meet after accomplishing their assigned tasks.

c. Restriction of Movement. In order to avoid compromising the OP locations, there should be little movement in the vicinity of the OP's. All personnel should make maximum use of concealment. Vehicles should *always* be left well to the rear of the area being reconnoitered.

d. Principles. In order to efficiently and effectively conduct the ground reconnaissance, the sound platoon commander should observe the following principles:

- (1) Keep the reconnaissance party as small as possible.
- (2) Assign specific tasks to each individual.
- (3) Orient every member of the party on the routes to be used and when and where to rendezvous.
- (4) Restrict movements in the area.
- (5) Obtain all available information on the current situation before starting the reconnaissance and any information that may be available from troops in this area to be reconnoitered.

e. The reconnaissance party should be composed of the minimum essential personnel. Higher headquarters will often direct that a reconnaissance party be made up of certain vehicles, equipment, and personnel. No one directive or list can possibly outline a party which is suitable for all situations. The personnel, equipment, and vehicles listed below are representative of a typical reconnaissance party.

- (1) A typical reconnaissance party and loading plan is as follows:
 - (a) Vehicle no. 1.
 - Sound platoon commander.
 - Chief surveyor.
 - Senior sound observer.
 - Wire team chief.
 - (b) Vehicle no. 2.
 - Recon-survey officer.
 - Sound chief.
 - Senior sound observer.
 - Wire team chief.
- (2) *Equipment.* Typical items of equipment required by the reconnaissance party include:
 - (a) Maps.
 - (b) Field glasses.
 - (c) M2 compass.
 - (d) Orienting stakes.
 - (e) Position markers.

CHAPTER 6

SOUND RANGING BASE COMPUTATIONS

32. Requirements for Computations

In order for the sound platoon to locate a sound source by sound ranging, with reference to a grid, the microphone of the sound ranging base must be accurately located (para. 36b); that is, the grid coordinates of each microphone position must be known or determined by survey.

a. Regular Bases. Because the microphones of a regular base must be separated by a definite distance and must have a specific linear relation, the coordinates desired for the microphone positions must first be computed and then the positions must be located on the ground by survey operations. In order to compute the coordinates of the microphone positions, the following data must be known:

- (1) The subbase length.
- (2) The number of microphones.
- (3) The radius of the base, if curved.
- (4) The azimuth of the base.
- (5) The coordinates of a point on the base (microphone or midpoint).

b. Irregular Bases. Since the microphones of an irregular base do not have a defined subbase length or linear relation, the desired points are located on the ground by map or ground reconnaissance, and their coordinates are determined accurately by survey operations.

c. Accuracy Checks. Independent computations must be made by two computers, each working independently of the other and checking results after the computations have been completed. DA Forms 6-1 and 6-2 are used for the computations. A rough sketch constructed by each computer, showing the orientation and location of the microphones relative to the grid lines, is an aid in detecting gross errors.

33. Computation of a Straight Regular Base

The computations necessary for a straight regular base are illustrated in figure 15.

a. Microphone Position Coordinates. Microphone position coordinates are determined by using DA Form 6-2 (for details, see FM 6-2). The coordinates are computed in the same manner as in a 1:1000 traverse (FM 6-2) by using the subbase length as the horizontal distance and the azimuth of the base as the azimuth to the forward station. In the example shown in figure 15, the known data are as follows:

Subbase length—1,350.4 meters (4 sound seconds).

Number of microphones—six.

Azimuth of the base—5,000.00 mils (M_1 to M_6).

Coordinates of M_3 —(284056.0—182385.0).

From these known data, the dE and dN (difference in easting and northing) between M_3 and M_4 are determined as minus 1,324.45 meters and plus 263.45 meters, respectively. Since this is a straight regular base, in moving from M_3 to M_4 or from any microphone to the next higher numbered microphone, the E coordinate is decreased by 1,324.45 meters and the N coordinate is increased by 263.45 meters. Starting with the known coordinates of M_3 , the coordinates of M_5 and M_6 are determined as follows:

Position	Coordinates	
	<i>E</i>	<i>N</i>
M_3	284045.00	182385.00
dE and dN	—1324.45	+263.45
M_4	282720.55	182648.45
dE and dN	—1324.45	+263.45
M_5	281379.10	182911.90
dE and dN	—1324.45	+263.45
M_6	280071.65	183175.35

In moving in the opposite direction, from M_3 to M_2 or from any microphone to the next lower

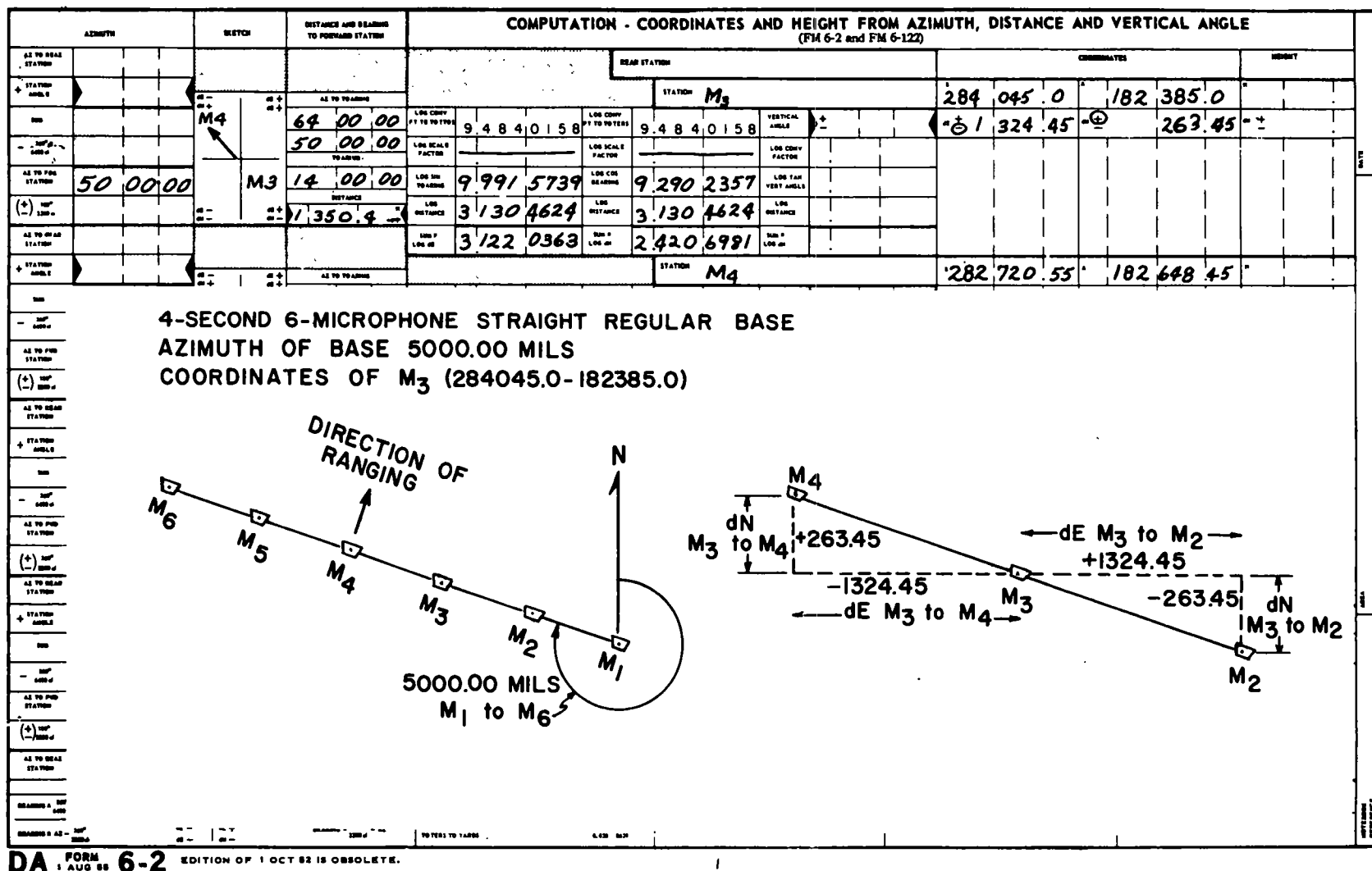


Figure 15. Sketch and computations for a straight regular sound base.

numbered microphone, the same dE and dN are applied but with opposite signs. Starting with the known coordinates of M_3 , coordinates of M_2 and M_1 are determined as follows:

Position	Coordinates	
	E	N
M_3	284045.00	182385.00
dE and dN	+1324.45	-263.45
M_2	285369.45	182121.55
dE and dN	+1324.45	-263.45
M_1	286693.90	181858.10

As a check, the difference between the E coordinates of M_1 and M_6 should be 5 times dE , and the difference between the N coordinates of M_1 and M_6 should be 5 times dN .

b. Midpoint Coordinates. In many instances, the coordinates of the midpoint of the sound base, C_3 (midpoint between M_3 and M_1), will be given as the known point on the sound base. If this is the case, the computation procedure is the same except that the dE and dN determined between C_3 and M_3 or M_1 is one-half the dE and dN between adjacent microphones, and only one-half the subbase length is used in the determination of the dE and dN . Therefore, as soon as the coordinates of M_3 and M_1 have been determined, the computed dE and dN are doubled in determining the coordinates of the remaining microphone positions.

34. Computation of a Curved Regular Base

The computations necessary for a curved regular base are illustrated in figures 16 and 17.

a. Microphone Position Coordinates. Microphone position coordinates are determined by using DA Form 6-2 as for the straight regular base; however, since each subbase has a different azimuth, a dE and dN must be computed and applied for each subbase. In the example shown in figures 16 and 17, the known data are as follows:

Subbase length—1,700 meters.

Number of microphones—six.

Radius of base—13,600 meters (ratio of 1:8).

Azimuth of base—1,300.00 mils (M_1 to M_6).

Coordinates of M_3 —(277740.0-192715.0).

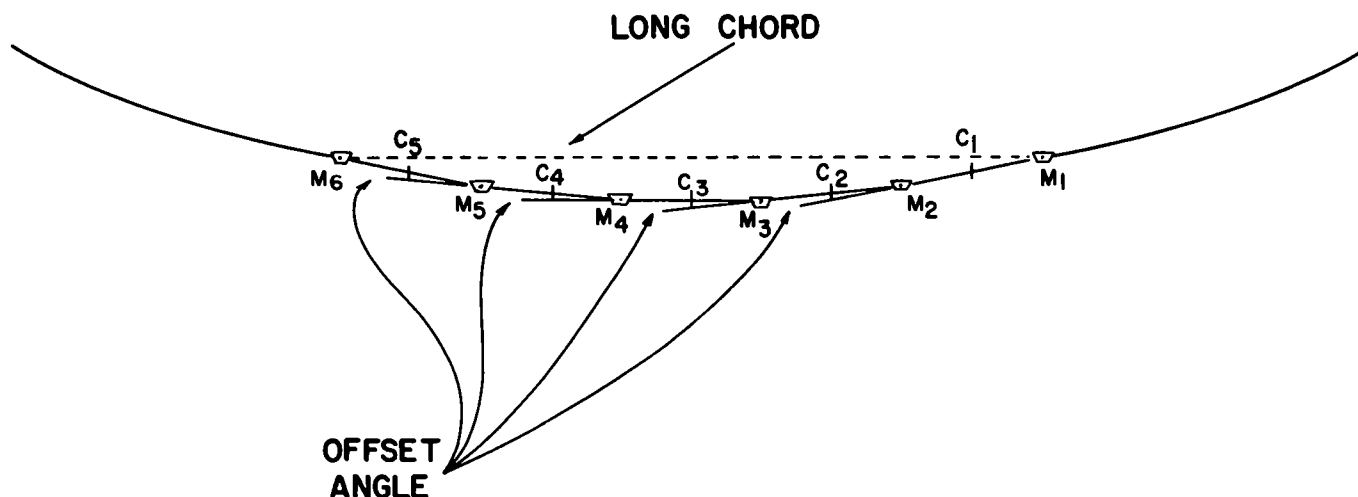
From these known data, the value of the offset angle (azimuth difference between any two adjacent subbases) can be determined from table VII, appendix V, as 127.16 mils. The value of the offset angle determined from the table is used to compute the azimuth of each subbase, as illustrated in figure 16. (Note that the azimuth from M_3 to M_1 is the same as the azimuth from M_1 to M_6 .) The subbase length is then used as the horizontal distance, and the azimuth of each subbase, in turn, is used as the azimuth to the forward station to compute the coordinates of each microphone. These computations are illustrated in figure 17. As a check, the coordinates of M_6 can be computed by using the distance from M_1 to M_6 , the azimuth from M_1 to M_6 , and the coordinates of M_1 . For the computations illustrated in figure 17, the log L factor from table VII, appendix V, is used to convert the subbase length to the long chord length. The check coordinates for M_6 will agree within 1 meter with the originally computed coordinates if the proper computations have been performed.

b. Midpoint Coordinates. If the coordinates of the midpoint of the sound base, C_3 (midpoint between M_3 and M_1), are given as the known point on the base, the same procedure is used to determine the coordinates of M_3 and M_1 as that employed in a straight regular base to determine the coordinates of M_3 and M_1 . From that point on, the computation is the same as that when the determined coordinates of M_3 (or M_1) are the known point given on the base.

35. Computation of an Irregular Base

The coordinates of the microphone positions of an irregular sound base are determined by survey operations in the same manner as the coordinates of the stations of a traverse. (See FM 6-2 for explanation of traverse computations.)

1,700-METER SUBBASE 6-MICROPHONE CURVED REGULAR BASE
 AZIMUTH OF BASE 4500.00 MILS
 RADIUS OF BASE 13,600 METERS (1:8)
 OFFSET ANGLE 127.16 MILS
 COORDINATES M_3 (277740.0-192715.0)



SUBBASE AZIMUTH + OFFSET ANGLE = AZIMUTH NEXT HIGHER NUMBERED SUBBASE
 SUBBASE AZIMUTH - OFFSET ANGLE = AZIMUTH NEXT LOWER NUMBERED SUBBASE
 AZIMUTH M_1 TO M_6 = AZIMUTH M_3 TO M_4 (PARALLEL LINES)

AZIMUTH M_3 TO M_4 = 4500.00 m
 + 127.16 m

AZIMUTH M_4 TO M_5 = 4627.16 m
 + 127.16 m

AZIMUTH M_5 TO M_6 = 4754.32 m

AZIMUTH M_3 TO M_4 = 4500.00 m
 - 127.16 m

AZIMUTH M_2 TO M_3 = 4372.84 m
 - 127.16 m

AZIMUTH M_1 TO M_2 = 4245.68 m

Figure 16. Computation of curved regular sound base subbase azimuths.

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27.

CHAPTER 7

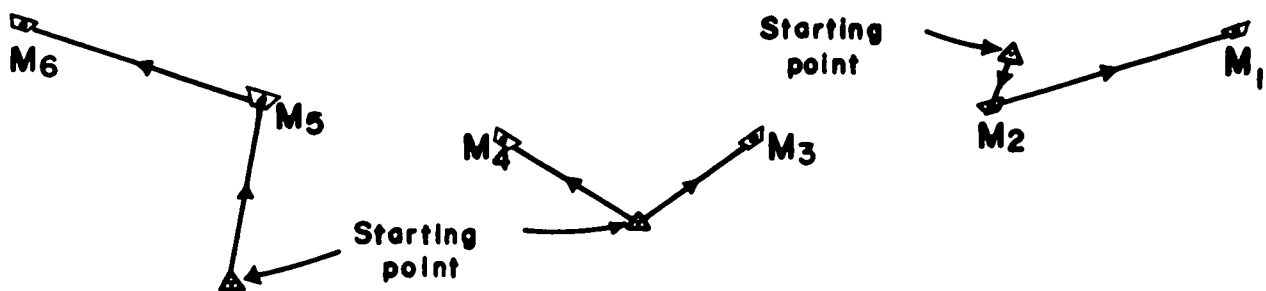
SOUND RANGING BASE SURVEY

Section I. PRECISE METHODS

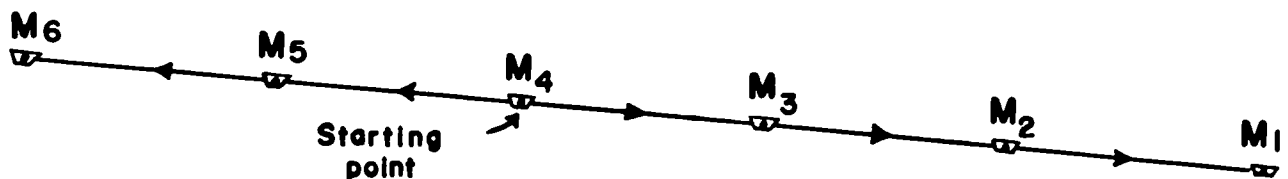
36. General

a. Methods. The microphones of a sound ranging base will be located, whenever possible, by the survey methods described in FM 6-2. Normally this will require 6 to 8 hours.

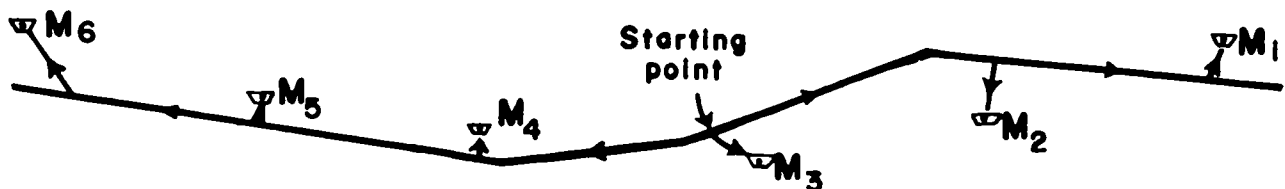
b. Internal Survey. The internal survey of a sound ranging base consists of locating and marking the microphone positions on the ground in their correct relative positions independent of common survey control. It may be



① Short traverses from survey control points



② Traverse along line of a straight base



③ Offsets from traverse along a road

Figure 18. Methods of surveying sound bases.

performed either by the precise methods described in FM 6-2, or by the hasty methods covered in paragraphs 39 through 42.

c. External Survey. The external survey of a sound ranging base consists of the operations necessary to place the sound ranging base on common survey control with the firing units. It is performed by the precise survey methods described in FM 6-2. External survey may also be performed by the approximate methods described in paragraph 78.

37. Survey of Regular Bases

As soon as practicable after the location of the sound ranging base has been determined by a map and ground reconnaissance and the coordinates of the microphone positions have been computed, the microphone positions are located on the ground at their computed positions by precise survey operations. Traverse is the most frequently used survey method. If survey con-

trol is available at a point on or near the base, the internal survey may start from this point. If survey control is not available, the internal survey may be started from a convenient point assigned arbitrary coordinates. Conversion to common survey control (common grid) by external survey is completed as soon as possible. If sufficient survey control points exist in the vicinity of the sound base, a short traverse may be run to each microphone position from the nearest control point (fig. 18).

38. Survey of Irregular Bases

Microphone positions will be located and marked on the ground so that the coordinates of the marked positions can be determined by survey. In this case, microphone positions are usually located by traverse; however, on suitable terrain, survey may be accomplished by triangulation or a combination of triangulation and traverse.

Section II. RAPID METHODS

39. General

a. When there is insufficient time to employ precise survey methods in the internal survey of the sound base, the internal survey may be initially accomplished by one of the rapid, or hasty, methods. Unless the tactical situation prohibits it, this initial internal survey will always be improved by precise survey as soon as practicable. The rapid, or hasty, methods include map inspection, calibrated cable (or pacing), and shot-in. One to two hours are required to install sound base by a rapid method.

b. When the internal survey of the base has been performed by using one of the hasty methods described in paragraphs 40 through 42, it is desirable to place an approximate grid on the sound ranging plotting chart. If map inspection is used, the grid reference of each microphone and the azimuth of each subbase are determined directly from the map. The chart is then prepared in the normal manner (para. 75-77). When one of the other rapid methods is used, the grid may be placed on the chart by inspec-

tion or by firing. The firing method of placing a grid on a sound ranging plotting chart is discussed in paragraph 78.

40. Map Inspection

If an adequate map or photomap is available, the microphone positions of a sound ranging base may be located by map inspection. When this method of location is used, the microphone positions are located either at terrain features which can be identified on the map (photomap) and the ground or a short distance from such features. If the microphone positions are a short distance from identifiable features, the distance and direction are scaled from the map and the point is then located on the ground by using a compass for direction and then pacing for the distance; this method, in effect, is a short traverse. This method is rapid and is accurate enough for sound-on-sound adjustments if a sufficient number of recognizable features exist on the map (photomap) and the ground. It is particularly valuable in very rough terrain. Both regular and irregular sound bases can be located by this method.

41. Calibrated Cable

In the calibrated cable method of rapid internal survey, two taping parties working in opposite directions from a central starting point measure the distance between microphone positions with a piece of field cable of known length. (The same procedure can be carried out by two parties of two men each who have previously calibrated their pace, determining the distance between microphone positions by pacing.) The starting point is usually the midpoint of the base or one of the microphone positions; this point is marked on the ground with a range pole or flag. Another range pole or flag is then placed 100 to 200 meters away along the base to indicate the direction along which the parties should move. Each party taping or pacing the base, using the range poles or flags as a reference, picks a distant terrain feature as a further means of alinement with the range poles or flags and moves out on the survey operations, maintaining the alinement by eye. Alinement is further aided if additional range poles or flags are stationed along the base as the parties move along in their survey operations. A single strand of field cable one-fourth sound second (84.4 meters) in length is satisfactory for use in most terrain. No attempt is made to keep this cable horizontal in taping operations; it is allowed to lie on the ground. Great care should be taken to avoid error in the total number of tape lengths measured; taping pins or a counter should be used. Tapemen should move at double time between tape lengths. This method of internal survey is most suitable for open, fairly flat terrain and is especially advantageous when a long straight road is available to aid in maintaining alinement. The method is very rapid and is usually the most accurate method of internal survey. Although normally used to establish a straight base, this method can be used to establish an irregular base.

42. Shot-In Base

When satisfactory maps or photomaps are not available or when rough or heavily wooded terrain makes other rapid methods of survey difficult or impossible, the sound base may be shot-in. Microphone positions are selected ar-

bitrarily on the ground, approximating a straight regular base as much as possible. Relative positions of the microphones are then located by sound ranging by the method described in *a* through *d* below.

a. Determination of the Distance From the Microphone Positions to a Point Away From the Base. A shot point (position at which an explosive charge is detonated) is selected in front of, or to the rear of, the sound base. This point should be as nearly opposite the center of the base as possible and should be at least one sub-base length from the base. If feasible, it should not be at the observation post position, since this would call undue attention to the position; however, it may be on the line route to the sound observation post some distance short of the actual position. A cable is run from the sound recording set to the shot point, and the electrical connections shown in figure 19 are made at the shot point. At the sound recording set, the shot point cable is connected to a recording channel. When the cable connections and charge have been prepared, the shot point operator moves with his telephone to a safe distance (30 to 50 meters) from the charge which consists of from 1 to 5 pounds of explosive, depending on acoustical conditions. When the shot point operator has moved to a safe distance, he reports READY to the sound recording set operator, who starts the second recording operation of the set and announces FIRE. The shot point operator waits 5 to 10 seconds and then detonates the explosive charge. The exploding charge breaks the cable to the sound recording set and causes a "break" to appear on the sound record at the time the charge is fired. As the sound from the exploding charge travels across each microphone position, its time of arrival is recorded on the sound record. The time interval for the sound to travel from the shot point to each microphone can then be determined, corrected for existing weather conditions (*c* below) and converted to a distance by multiplying by 337.6 to obtain the corresponding distance in meters or by using table IV, appendix II.

b. Determination of the Distance Between Microphone Positions. A second shot point is selected at one of the interior microphone posi-

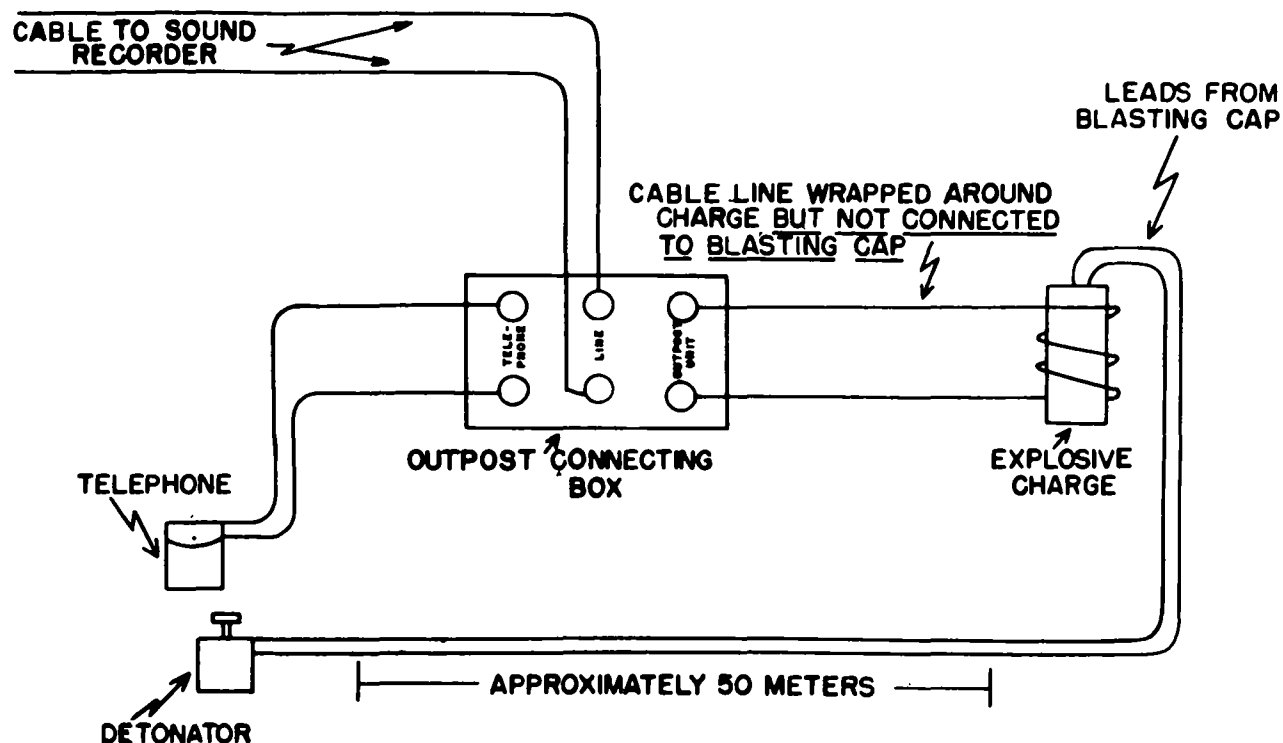


Figure 19. Electrical connections for shooting in a sound base.

tions. The microphone at this position is disconnected and removed approximately 50 meters to avoid damage to the microphone. The electrical connections shown in figure 19 are then made. When the connections and the explosive charge have been prepared, the same procedure is carried out that is used at the shot point in *a* above. Distances from this microphone position to the other microphone positions are computed in the same manner as in *a* above. The microphone is then emplaced, and the cables are connected to it so that normal sound ranging operations can commence.

c. Weather Corrections. The time interval from the shot point to each microphone position is corrected for temperature and wind effects before it is converted to a distance in meters.

- (1) The temperature correction for each time interval is determined by the use of the temperature correction chart (fig. 62). The correction is found in the normal manner as described in paragraph 83.
- (2) The wind correction for each time interval is determined by the use of the

wind correction chart for any length of subbase (fig. 64). The correction is found in the normal manner as prescribed in paragraph 84, except that in computing the wind angle, the azimuth from the microphone position to the shot point is used rather than the azimuth of the subbase as in normal sound ranging operations. The azimuth from each microphone position to the shot point is computed by making an uncorrected plot of the microphone positions and shot points by the procedure described in *d* below. The approximate azimuth of any one subbase is determined by compass, map, or estimation and is used in conjunction with the angular measurements from the uncorrected plot of the positions to determine all other azimuths (fig. 20). These azimuths must be within 200 mils of the correct azimuth.

d. Plotting. The plotting procedures necessary for determining the relative locations of

AZIMUTH $M_3 - M_2$ MEASURED FROM MAP

ANGLES MEASURED AS INDICATED ON PLOT

AZIMUTH $M_2 - M_1 = 3100$ MILS
 - ANGLE $\theta = 1000$ MILS
 $M_3 - A = 2100$ MILS
 AZIMUTH $M_2 - M_3 = 6300$ MILS
 + ANGLE $\theta = 1200$ MILS
 $M_2 - A = 1100$ MILS

AZIMUTH $M_1 - M_2 = 6200$ MILS
 + ANGLE $\theta = 700$ MILS
 $M_3 - A = 500$ MILS
 AZIMUTH $M_1 - A = 500$ MILS
 AZIMUTH $M_4 - M_2 = 3200$ MILS
 - ANGLE $\theta = 600$ MILS
 AZIMUTH $M_4 - A = 2600$ MILS

AZIMUTH $M_2 - M_3 = 6300$ MILS
 + ANGLE $\theta = 100$ MILS
 AZIMUTH $M_2 - M_4 = 6400$ MILS
 - 3200 MILS
 AZIMUTH $M_4 - M_2 = 3200$ MILS
 AZIMUTH $M_2 - M_1 = 6300$ MILS
 + ANGLE $\theta_{wind} = 3100$ MILS
 AZIMUTH $M_2 - M_1 = 9400$ MILS
 - 3200 MILS
 AZIMUTH $M_1 - M_2 = 6200$ MILS

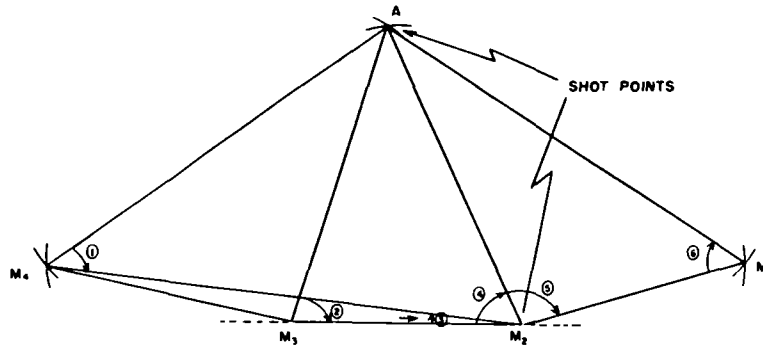


Figure 20. Determination of azimuths for wind correction.

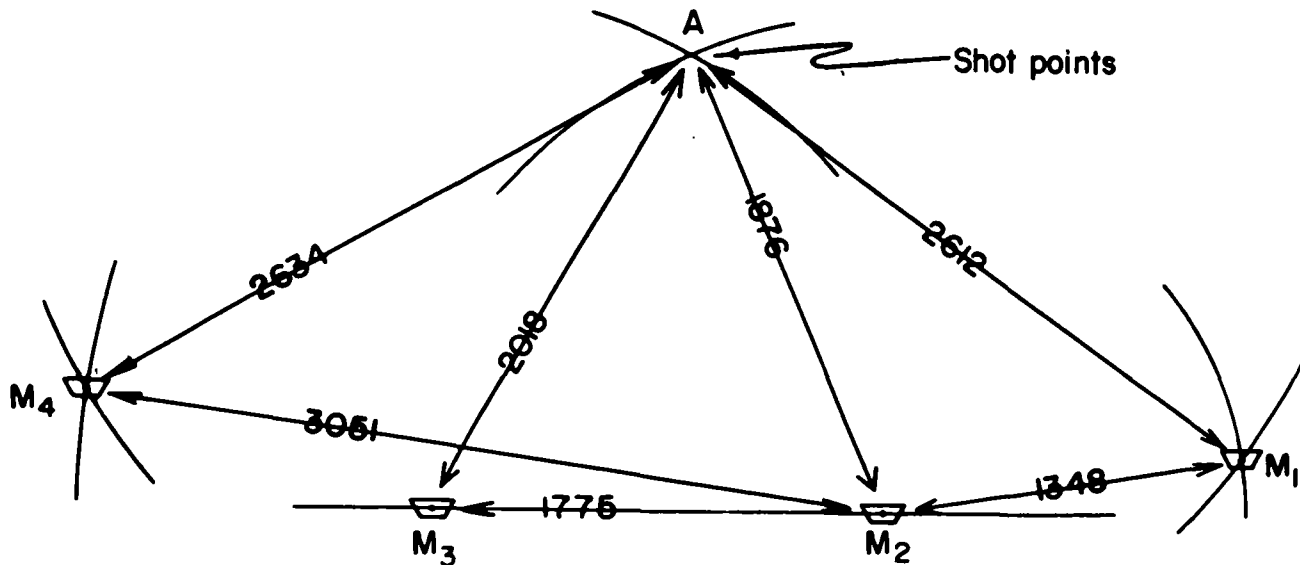


Figure 21. Plotting procedures for shot-in sound base.

RECORD NUMBER		SOUND PLOTTING RECORD						DATE	
		(FM 6-122)						19	
METRO MSG TIME	TEMPERATURE	CONVERSION NUMBER	SUBBASE	AZIMUTH	LENGTH	CALC. FACTOR	BASE LOCATION		
0930	44 OF		1-2		M		FT. SILL, OKLA.		
			2-3		M				
WIND DIRECTION	WIND SPEED	WIND CORRECTION	3-4		M		BASE TYPE		
1500	13 MPH		4-5		M		4 MIC IRREGULAR SHOT IN		
			5-6		M				
TIME READINGS									
RESULTS TO (-)									
1		M1 40.183	M3 41.448	M4 45.267	5	6			
RESULTS TO (+)									
		M2 36.160	M2 36.160	M2 36.160					
ST ST ST C4 C5									
	-	+	-	+	-	+	-	+	-
TIME INTERVAL		4.023		5.288		9.107			
TEMP CORR. @ TEMP CONVERTED TIME	.023		.031		.054				
WIND CORRECTION	.007		.000		.016				
SUB TOTALS	.030	4.023	.031	5.288	.070	9.107			
SUBTRACT		.030		.031		.070			
WEATHER CORRECTED TIME INTERVAL		3.993		5.257		9.037			
CURVATURE CORRECTION									
SPEED OF SOUND FINAL TIME INTERVAL METERS/SECOND		337.6		337.6		337.6			
APPROXIMATE DISTANCE	1,348 METERS		1,775 METERS		3,051 METERS				
FROM (FILE NO)	TIME REPORTED				GRID REFERENCE		ACCURACY		TIME ACTIVE
				NATURE OF TARGET (TO INCLUDE CALIBER)		REMARKS (AREA SHELLS, CONTROL)		FROM TO	
								CONC NR	

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Figure 22. Computations for distances from M_2 to other microphone positions.

the microphone positions are illustrated in figure 21. A line is drawn near the lower edge of the sound plotting chart to represent the line of subbase M_2 - M_3 . A point on this line is arbitrarily selected as the position of M_2 . A point on this line is then plotted to scale at the computed distance of subbase M_2 - M_3 to the left of M_2 , thereby locating M_3 . Point A, the shot point away from the sound base, is located by the intersection of arcs from M_2 and M_3 struck at the computed distances from M_2 and M_3 to the shot point. The positions of M_1 and M_4 are then located by the intersection of arcs from M_2 and point A struck at the computed distances from M_2 and point A to M_1 and M_4 .

e. *Illustrative Example.* The computations and plotting necessary for a shot-in sound base are illustrated in figures 21, 22, and 23. In this example, explosive charges were fired at M_2 and at a point in front of the sound base, called point A. Figure 22 illustrates the computations necessary to determine the distances from M_2 to M_1 , M_3 , and M_4 , whereas figure 23 illustrates the computations necessary to determine the distances from point A to each microphone position. Figure 21 shows the plotting procedures used to locate the relative positions of the microphones in order to set up a plotting chart.

RECORD NUMBER <u>2</u>		SOUND PLOTTING RECORD (FM 6-122)						DATE _____ 19__	
METRO MSG TIME <u>0930</u>	TEMPERATURE <u>44</u> OF	CONVERSION NUMBER	SUBBASE 1-2	AZIMUTH M	LENGTH M	CALC. FACTOR	BASE LOCATION <u>FT. SILL, OKLA</u>		
WIND DIRECTION <u>1500</u>	WIND SPEED <u>13</u> MPH	WIND CORRECTION	2-3	M	M	M	BASE TYPE <u>4 MIC IRREGULAR SHOT IN</u>		
			3-4	M	M	M			
			4-5	M	M	M			
			5-6	M	M	M			
TIME READINGS									
RESULTS TO (-)									
1	<u>2 M1 29.228</u>	<u>2 M2 27.023</u>	<u>4 M3 27.448</u>	<u>5 M4 29.308</u>					
RESULTS TO (+)	<u>A 21.520</u>	<u>A 21.520</u>	<u>A 21.520</u>	<u>A 21.520</u>					
	<u>21</u>	<u>22</u>	<u>23</u>	<u>24</u>				<u>C 5</u>	
TIME INTERVAL	-	+	-	+	-	+	-	+	
		<u>7.708</u>		<u>5.503</u>		<u>5.928</u>		<u>7.788</u>	
TEMP CORR. OR TEMP CONVERTED TIME	<u>.045</u>		<u>.032</u>		<u>.034</u>		<u>.046</u>		
WIND CORRECTION		<u>.073</u>		<u>.087</u>		<u>.083</u>		<u>.060</u>	
SUB TOTALS	<u>.045</u>	<u>7.781</u>	<u>.032</u>	<u>5.590</u>	<u>.034</u>	<u>6.011</u>	<u>.046</u>	<u>7.848</u>	
SUBTRACT		<u>.045</u>		<u>.032</u>		<u>.034</u>		<u>.046</u>	
WEATHER CORRECTED TIME INTERVAL		<u>7.736</u>		<u>5.558</u>		<u>5.977</u>		<u>7.802</u>	
CURVATURE CORRECTION									
SPEED OF SOUND FINAL TIME INTERVAL METERS / SECOND		<u>337.6</u>		<u>337.6</u>		<u>337.6</u>		<u>337.6</u>	
APPROXIMATE DISTANCE	<u>2,612 METERS</u>	<u>1,876 METERS</u>	<u>2,018 METERS</u>	<u>2,634 METERS</u>					
FROM (FILE NR) / TIME REPORTED	GRID REFERENCE				ACCURACY		TIME ACTIVE		
							FROM _____ TO _____		
	NATURE OF TARGET (TO INCLUDE CALIBER)				REMARKS (AREA SHELLED, CONTROL)			CONC	
								NR	

DA FORM 6-4
1 OCT 58

REPLACES EDITION OF 1 MAR 55, WHICH IS OBSOLETE.

Figure 23. Computations for distances from point A to all microphone positions.

CHAPTER 8

INSTALLATION, OCCUPATION, AND ORGANIZATION OF SOUND RANGING INSTALLATIONS

Section I. GENERAL

43. General

After the ground reconnaissance and final selection of positions have been completed, the survey and communication personnel are re-

leased to begin their part of the preparation of the new positions while the sound personnel prepare to occupy the positions. If already operating an installation, the sound platoons will

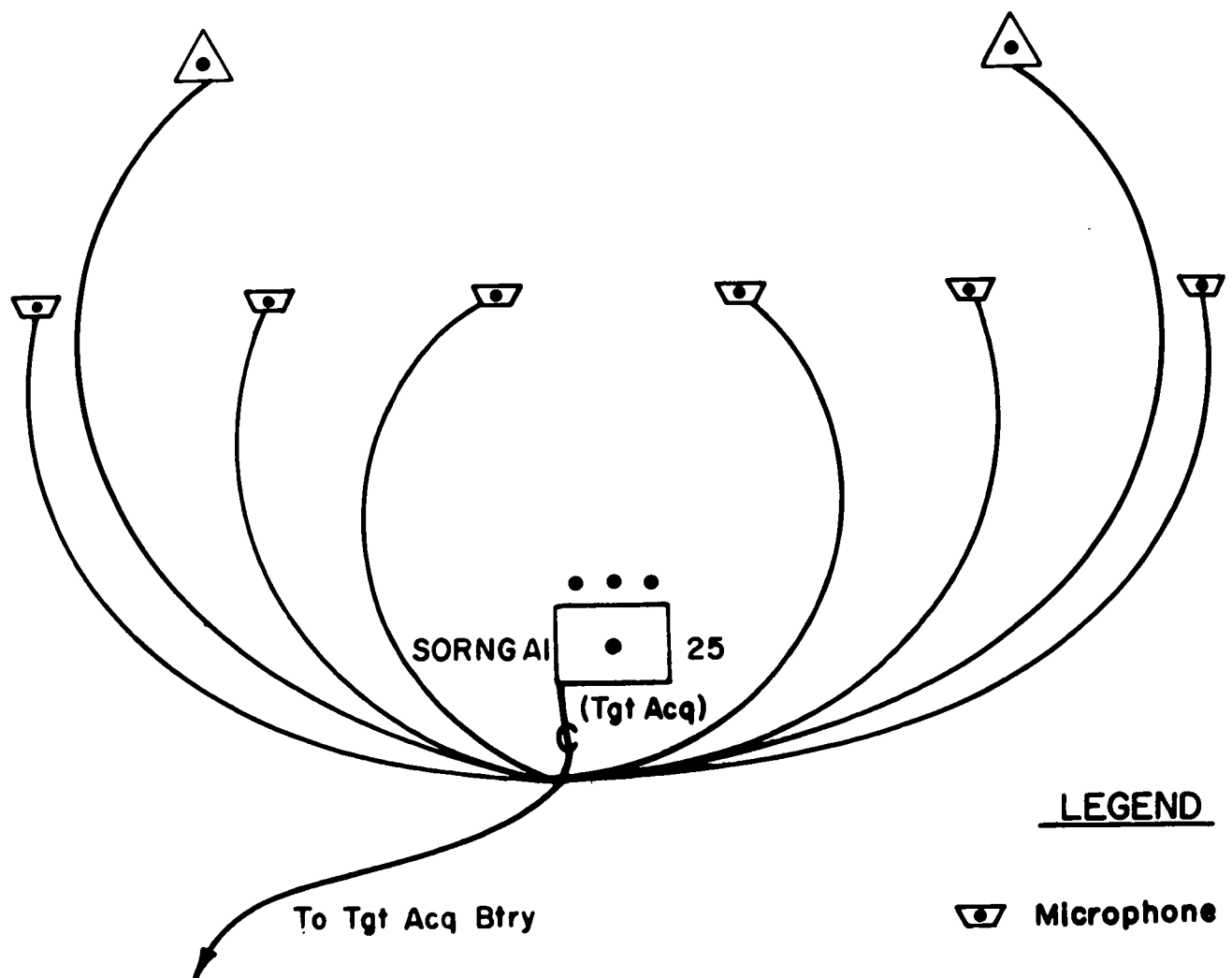


Figure 24. A typical sound platoon wire net.

continue to man the old position until ordered to displace; if the platoon is in bivouac or rendezvous, the selected positions will be manned immediately and normal operations begun as soon as possible. A number of operations will take place simultaneously; these include survey, installation of microphones, laying of cable lines, and occupation of the CP and OP areas.

44. Security

a. Since the OP's will be some distance from each other and from the CP, their security arrangements must be coordinated with those of the nearest unit or the unit within whose area they are positioned. Arrangements must be made, either during the reconnaissance or the occupation of position, to insure that the OP will be included within the perimeter defenses of some adjacent unit, usually on infantry company.

b. The defensive measures for the sound ranging CP should be coordinated with those of the nearest adjacent unit. An efficient warning system is necessary to provide early warning and information of infiltration, armored attacks, parachute drops, or air landings. See FM 6-10 and FM 6-140 for further details on defensive measures.

45. Communications

a. *Cable.* Cables are laid and maintained by battery personnel as shown in figure 24. The OP teams are responsible for laying and main-

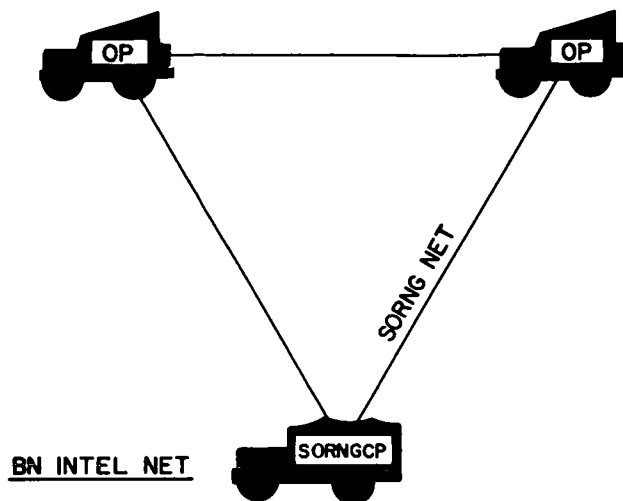


Figure 25. A typical sound platoon radio net.

taining cable from the OP to a cablehead established in the vicinity of the OP. For a detailed discussion of field wire techniques, see FM 24-20.

b. *Radio.* The sound platoon operates in the target acquisition battery and battalion intelligence net as shown in figure 25.

46. Survey

If a hasty occupation of position is necessary, sound platoon personnel will perform the internal survey of the sound ranging base by one of the methods described in chapter 7. Otherwise, battery survey personnel will perform the necessary survey according to the procedures outlined in FM 6-2.

Section II. SOUND RANGING OBSERVATION POSTS

47. Occupation of OP's

Each observer team occupies its OP over a separate route previously selected during the reconnaissance. Observation begins immediately on arrival at the position. All personnel must exercise great care during the occupation of position and during all future movement at the OP to avoid revealing the position to the enemy.

48. Organization of OP Position

a. *General.* Immediately on occupation of the OP, part of the observer team begins organiz-

ing the position while the remainder of the team begins observing. Organization of position includes the establishment of communications, preparation of field fortifications, and organization of observation.

b. *Communications.* The observer team checks into the radio net on arrival at the OP and operates in this radio net until cable communication is established. A change is then made to cable communication and the radio is placed in a monitoring role. Radio contact can be immediately re-established if cable communication fails. The observer team is responsible

for laying and maintaining its own cable to a local cablehead established by the battery communication personnel (usually a few hundred meters from the OP). When installation of cable is completed, the telephone at the OP is connected through the outpost connecting box to the cable (TM 11-2568).

c. Field Fortifications. Observing is done from a position which has a minimum of 3,200 miles unobstructed of sight and audio reception. Living quarters for the OP team members who are not on duty observing are constructed on the reverse slope or in some position offering cover and concealment. The living quarters should

be connected to the OP by a trench. See FM 5-15 for a discussion of field fortifications.

d. Organization of Observation. Immediately on occupation of position, the observer determines the direction to the enemy; this is done by means of a compass or a map. The OP personnel systematically search the target area, noting the direction to all critical terrain features. Maps and aerial photographs, if available, are studied and are correlated with the target area by identifying terrain features both, on the map (photograph) and in the target area. As an aid in observation, a panoramic sketch of the zone of observation is made for each OP.

Section III. MICROPHONE BASE

49. General

Usually, microphones are installed by battery communication personnel, but they may be installed by sound platoon personnel. The communication link between the microphones and the sound recording set may be either cable or radio, depending on the conditions under which the base is being installed.

50. Microphone Cables

Because microphones operate at a potential of 90 to 125 volts, their efficiency is seriously impaired by electrical leakage through the cable insulations; therefore, great care must be exercised in laying microphone cables to avoid damage to cable insulation. Splices must be carefully made and well insulated to avoid excessive leakage or possible shorts. Lines which would operate satisfactorily as telephone circuits may be inoperative as microphone lines. In most instances, microphone lines are laid from the sound CP to the microphone positions. Microphones should be pretested prior to the departure of the wire teams from the CP. On arrival at a microphone position, the cable is cut, tied in, and tested. Sufficient slack is coiled at the position to allow movement of the microphone to the correct position if survey of the position has not been completed. A microphone is then connected to the line and tested (TM 11-2568). If the line and the microphone are both found to be operative, the microphone is

emplaced by one of the methods discussed in paragraph 52.

51. Radio Sound Data Transmission Systems

a. General. Under some operational conditions it will be necessary to install a sound ranging base in which some or all of the cables to the microphones are replaced by a radio sound data transmission system. Such conditions occur when weather, terrain, available time, heavy vehicular traffic, or sustained enemy artillery fire delay or make impossible the installation and maintenance of cables.

b. Employment. The radio system used for sound data transmission is separate from the normal radio communication system between the OP and the CP; however, the equipment may be tested by voice communication over the same system. The purpose of the system is to transmit to the sound recording set the detections of sound waves by the microphones.

c. Installation. The use of the radio sound data transmission system facilitates hasty occupation of position and rapid displacement and serves as a means of data transmission in those situations where the installation of cable is impracticable. The number of microphones operated on the radio system depends on the requirements of each individual situation. In most cases, it will be possible to complete one or more of the shorter microphone circuits by

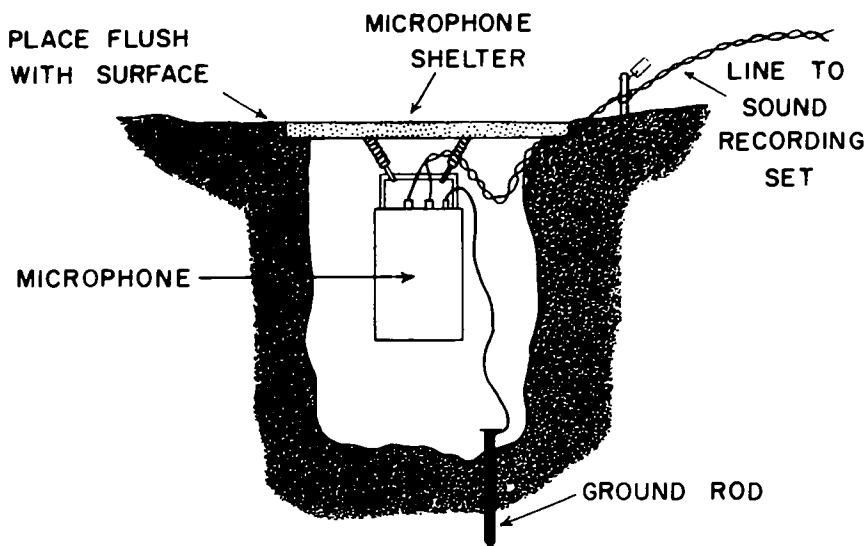


Figure 26. Microphone emplacement, normal installation.

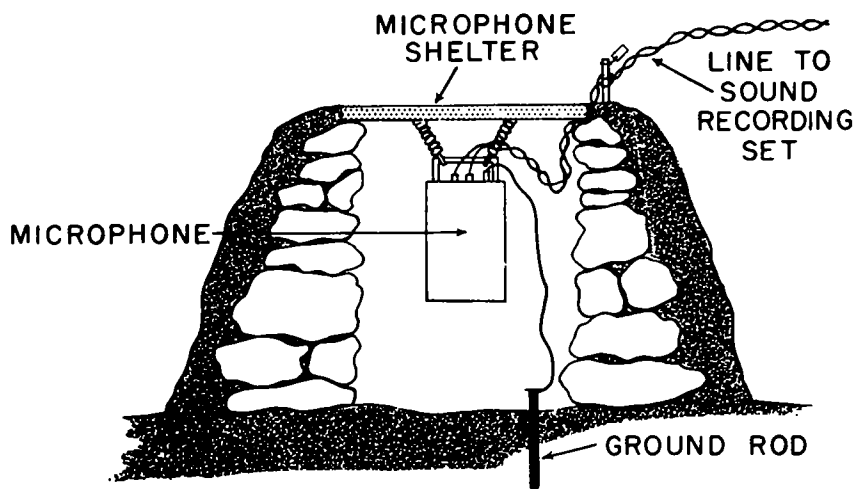


Figure 27. Microphone emplacement, rocky ground installation.

cable while radio connections to other positions are being established. As a result, in any one sound ranging base, at least a portion of the installation will utilize cable circuits even though the radio system provides sufficient means to operate all installations by radio. The mechanics of installation are carried out by battery communication personnel.

52. Emplacing Microphones

Sound ranging microphones should be installed so as to be shielded as much as possible

from the direct effects of wind and other disturbances. In the standard installation shown in figure 26, the microphone is suspended in a hole approximately 18 inches deep and 14 inches in diameter. The microphone is suspended by spring-mounted hooks from the standard microphone shelter, a flat canvas cover on a metal frame. If, because of the character of the ground, a microphone hole cannot be dug, a support such as that illustrated in figure 27 may be built of stones and earth or some similar material. Regardless of the method of emplacement used, the microphone must be sheltered

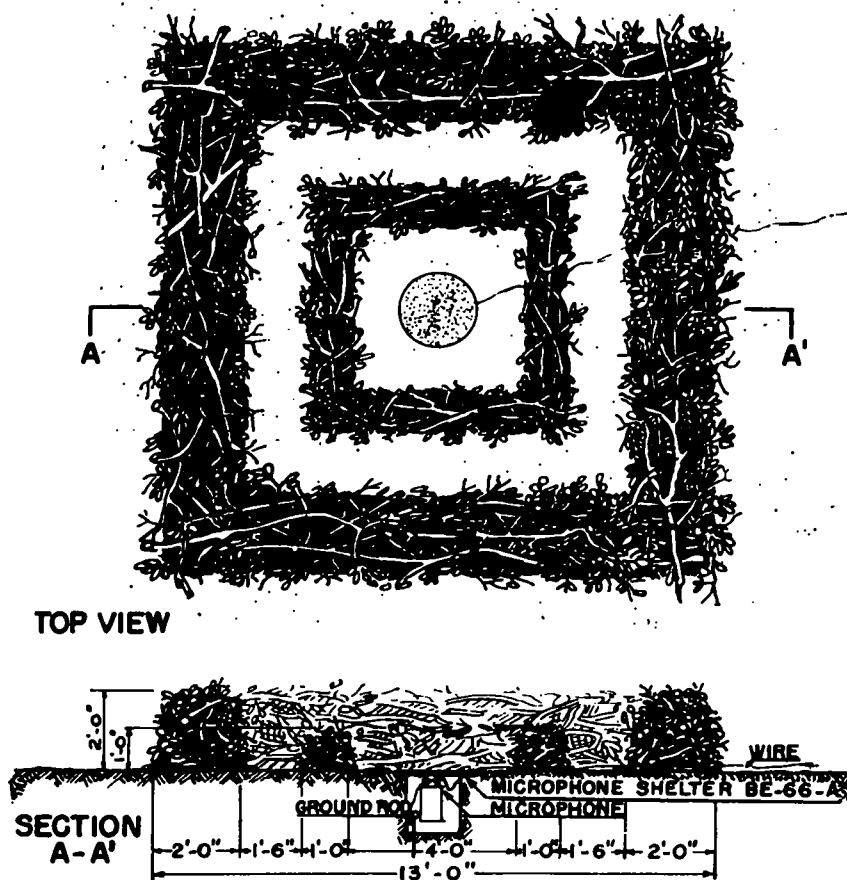


Figure 28. Microphone emplacement, sheltered with two rows of cut brush.

from the wind. In the situations noted, the following means of shelter are listed in order of preference.

a. When operations are conducted in wooded terrain, the individual microphone positions should be selected in woods or heavy underbrush, near the edge of such vegetation, toward the sound source. If selected too far inside such woods or heavy underbrush, the sound wave may be damped out before it arrives at the microphone position. If it is impossible to place microphones near the edge of woods or heavy underbrush, shelter should be achieved by surrounding each microphone with two rows of cut brush. Such a shelter is illustrated in figure 28.

b. In the absence of woods or cut brush, the British wind screen, SR, No. 2, Mark 1, should be used. To be effective, this method of shelter

requires a hole with the dimensions illustrated in figure 29.

c. When none of the above methods is feasible, earth or hay may be used as a hasty method of emplacing; this method will slightly reduce the effects of wind. When earth is used, a layer of loose earth approximately 6 inches in depth is placed on top of the standard microphones shelter; when hay is used, a pile of hay (pine needles or grass may also be used) approximately 3 feet in diameter and 3 feet high is placed on top of the standard microphone shelter (fig. 30). In hasty sheltering, care must be taken that approximately the same depth of material is placed over each microphone in order that the resultant effect on the sound wave at each microphone will be approximately the same.

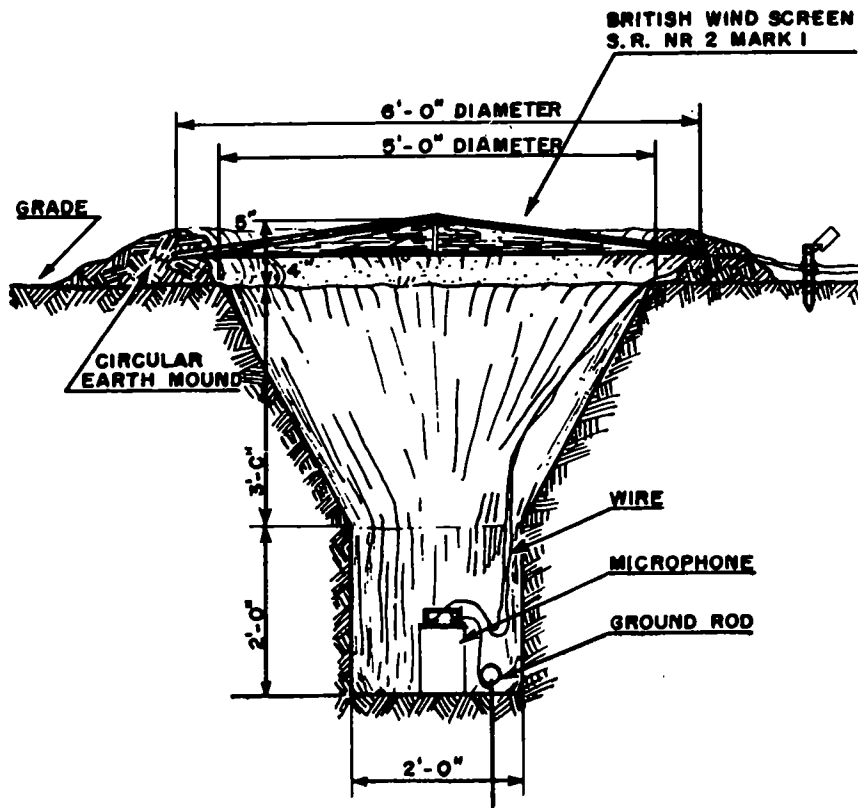


Figure 29. Microphone emplacement, using the British wind screen, SR, Number 2, Mark 1.

53. Connecting Telephone to Microphone Circuit

A telephone may be connected to any microphone circuit as required for communication with the sound CP. It must be disconnected when the microphone is being tested since the microphone is inoperative when the telephone is connected unless the connection is made through the outpost connecting box or other capacitor unit. Telephones must not be connected to a microphone circuit when sound ranging is in progress.

54. Avoiding Shocks

When the circuit test key on the sound recording set is in other than the normal position, a high potential is applied to the microphone line. To avoid shocking the wireman, the sound recorder leaves the key in the normal position until the wireman calls for a microphone test.

He then moves the key to the circuit test position *after* the wireman has had time to disconnect his telephone. The key is left in this position only for a short prearranged period of time.

55. Two Microphones on One Line

In an emergency, two microphones may be temporarily connected to a single microphone circuit. The first microphone is connected in the normal manner. When the second microphone is connected, a polarity test (TM 11-2568) must be made at the sound recording set. If this test indicates that the polarity of the second microphone is reversed, the leads at the microphone must be changed.

56. Emplacing Microphones After Resurvey

The position of a microphone will not be changed without notifying the sound CP. It is

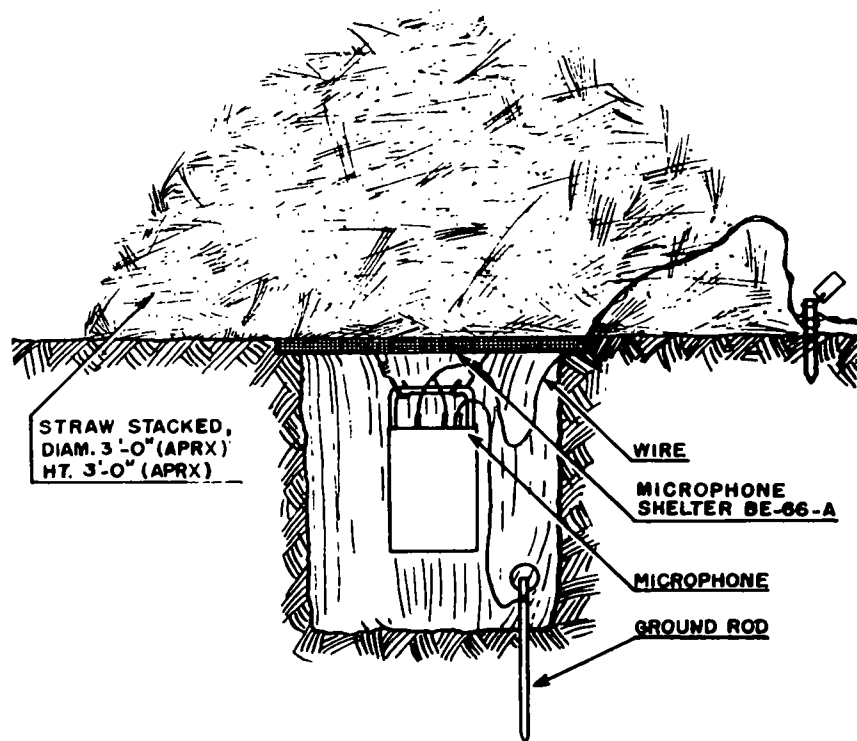


Figure 30. Microphone emplacement, hasty sheltering.

preferable that all necessary shifting of microphones be made simultaneously to avoid, as much as possible, the interruption of sound ranging. If long moves are necessary, it may be possible to install microphones at the new position and lay cables from them back to the

old position. The lines from the microphones at the old position are then disconnected and spliced into the new lines. This action permits the changeover to be made with minimum loss of time.

Section IV. SOUND RANGING COMMAND POST

57. Occupation of CP Position

On receipt of orders, the sound CP personnel will move along a designated route to the new position area. Movements in the vicinity of the position should be made at reduced speed. Care must be exercised to avoid areas not cleared of mines and to avoid making new vehicle or personnel tracks that will reveal the position to air observers. See FM 6-140 for a detailed description of the operations and procedures involved in occupying a new position area.

58. Organization of CP Position

a. *General.* The organization of position begins when the CP position area is selected, and

improvement continues throughout the occupancy. For a detailed discussion of the general procedures in the organization of position, see FM 6-140.

b. *Communications.* Communication personnel begin laying cable from the CP area toward the microphone positions. If the radio sound data transmission system is used, the communication personnel will set up the necessary radio equipment in the CP area, as well as at the microphone positions. After the cable or radio circuits have been completed, communication personnel assigned the task of maintaining the communication system of the sound platoon

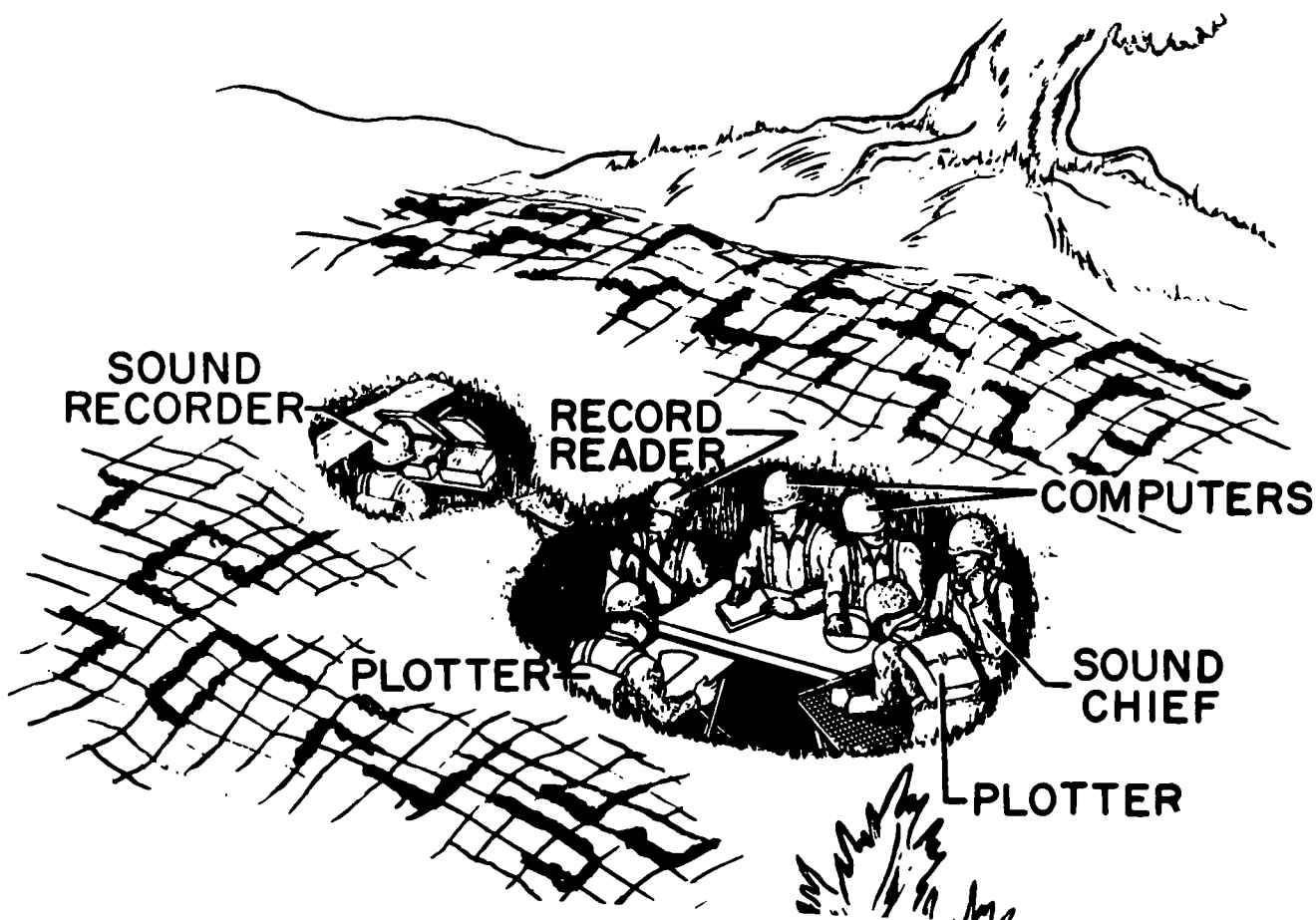


Figure 31. Sound ranging command post, hasty installation.

will remain at the CP whenever they are not engaged in maintaining the system.

c. Sound Ranging Command Post. The sound recording and plotting equipment and personnel are located near each other so that coordination between their activities may be achieved. The sound recording equipment is set up, tested, and prepared for operation, and communication circuits are connected and tested promptly. See TM 11-2568 for detailed instructions on setting up and testing the sound recording equipment. The sound plotting chart is prepared and the proper correction devices are positioned for ready use (ch. 11). Figure 31 shows the typical

organization and layout of a hastily occupied sound CP; this figure shows only that portion of the CP occupied by the sound recording and sound plotting equipment and personnel.

d. Personnel Shelters. A CP tent, or other type of shelter (which may be vehicular mounted), normally will be used to provide blackout facilities and shelter in inclement weather for equipment and personnel at the sound CP. Construction of fortified personnel shelters will begin immediately on occupation of position. See FM 5-15 for a detailed discussion of the construction of fortified shelters.

CHAPTER 9

DUTIES OF PERSONNEL AND THE EQUIPMENT OF SOUND RANGING OBSERVATION POSTS

59. General

Since the personnel manning the OP start the sound recording process, the effectiveness of sound ranging is directly proportional to the ability of these personnel. The sound OP is manned by an OP chief and two assistants. One observer is on duty at all times, while the other two members of the team improve the position or rest.

60. Duties of Personnel

a. Starting the Sound Recorder. On hearing a hostile weapon fire, the observer on duty depresses the outpost switch, which activates the sound recording set and sensitizes the microphones. As the sound wave of the weapon firing passes over the microphones, it is detected and the time of arrival is recorded at the sound recording set. The observer keeps the switch depressed until told to release it by the operator of the sound recording set at the CP.

b. Rendering the Observer's Report. After the set has been activated by the observer, the operator of the sound recording set requests a report. Those elements of the report which are available are announced in the sequence shown in (1) through (8) below.

- (1) Approximate azimuth from the OP to the hostile weapon firing.
- (2) Estimated distance from the OP to the hostile weapon firing.
- (3) Number of hostile weapons firing.
- (4) Estimated caliber of the hostile weapon firing.
- (5) Type of hostile weapon firing.
- (6) Whether a ballistic wave was detected from the hostile weapon firing.

(7) Estimated location of the point of impact of the hostile fire, if known.

(8) Whether friendly artillery was firing at the time.

c. Collecting Battlefield Information. In addition to starting the sound recording set when he detects the firing of hostile weapons, the observer reports to the sound CP any activity, either friendly or hostile, which he observes in his zone of observation.

d. Recording Reports. The observer on duty at the OP records all reports sent to, and received from, the sound CP. The reports are recorded in a notebook as they are sent or received. Care must be taken to insure that the time the activity is observed and the time the report is sent to the CP are recorded in the notebook; this procedure insures that all reports are actually rendered.

e. Adjusting Artillery Fire. All personnel of the OP team must be capable of adjusting artillery fire when called on to do so; these techniques are described in detail in FM 6-40. In addition, the sound OP personnel assist in sound-on-sound adjustments and sound ranging registrations.

f. Additional Duties. In addition to the duties listed in *a* through *e* above, the observer team maintains the cable from the OP to a local cablehead established in the vicinity of the OP by battery communication personnel, monitors its radio channel, maintains its equipment, and performs such other duties as prescribed by the sound platoon commander.

61. Equipment

To carry out its assigned duties, each obser-

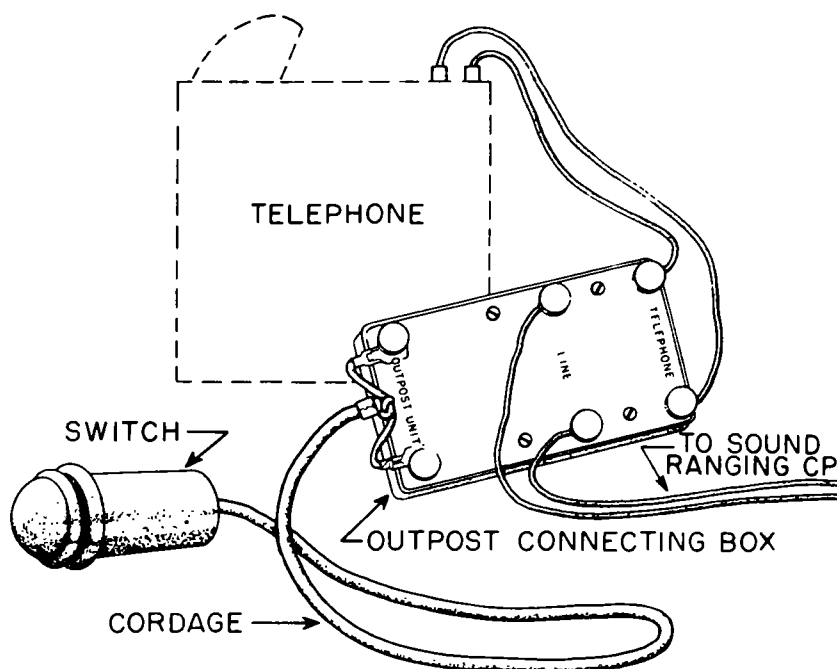


Figure 32. The Outpost Unit.

ver team is equipped with the items in *a* through *i* below.

a. Outpost Unit. The outpost unit consists of an outpost connecting box and a switch. The connecting box has three sets of terminals to which are attached the cable to the telephone, the cable to the sound recording set, and the switch. The outpost switch unit is a 6-foot length of cable with terminals at one end and a plunger-type switch at the other end which is used by the observer to start the sound recording set. When the switch is depressed, it causes the sound recording set to be activated. The connecting box allows conversation over the cable while the outpost switch is depressed. The proper installation of these devices is shown in figure 32. Detailed descriptions and functioning of the items are given in TM 11-2568.

b. Telephone. The telephone is connected to the proper terminals of the outpost connecting box to allow voice communication with the sound ranging CP. The telephone is operated by the observer on duty at the OP.

c. FM Radio. The FM radio is used to communicate with the sound ranging CP when cable is not installed or when cable communication fails.

d. Binoculars. The binoculars are used to examine the zone of observation for the detection of activity that will produce battlefield information.

e. Compass. The compass is used in the determination of azimuths to targets or points in the zone of observation.

f. Watch and Stopwatch. The watch is used to determine the time of observation or detection of targets, and the stopwatch is used for flash-bang ranging when the hostile weapons firing can be seen by the observer. See paragraph 137 for the procedures followed in flash-bang ranging.

g. Maps and Photographs. The latest maps, photomaps, and aerial photos of the zone of observation should be made available to the OP to aid the observers in target location. Marking

on the maps and photomaps is facilitated if they are covered with acetate and mounted on map boards.

h. Notebook and Pencil. The notebook and pencil are used for recording the reports made and received by the observer, to include the time of detection of the activity and the time the report was forwarded or received.

i. Other Equipment. Auxiliary equipment includes such items as cable maintenance equipment, spare cable, a metascope, pioneer tools, a vehicle (if practicable), spare batteries, and necessary individual equipment. The amount and completeness of this auxiliary equipment will depend on the location of the OP and the tactical situation.

CHAPTER 10

SOUND RECORD INTERPRETATION

62. Characteristics of the Sound Ranging Record

a. *General.* Sound ranging records are electrical recordings of the arrival times of sound waves at the microphone positions. The sound ranging set produces the record on a strip of special teledeltos paper approximately $3\frac{1}{4}$ inches in width. The technique of operating and maintaining the sound ranging set is described in TM 11-2568.

b. *Microphone Traces.* Six horizontal lines are traced on the record, one corresponding to each microphone installed in the sound base. The upper trace of the record represents impulses from M_1 ; the second, from M_2 ; etc. When no sound wave is being detected by a microphone, its corresponding trace is recorded as a straight line. When a sound wave is detected by a microphone, an electrical impulse is communicated to the sound-ranging set to a galvanometer assembly which, by means of a moving electrical stylus, reproduces this electrical impulse as a wavy line, called a break (fig. 33). The point at which the trace first departs from its straight line path, or *zero line*, is the *initial break*. The initial break may be either upward or downward from the zero line, depending on the internal connections within the sound ranging set, but it is desirable that all traces move in the same direction in the initial break. The low and high points on the wavy trace are called, respectively, *valleys* and *peaks (crests)* (fig. 33). The total elapsed time from the initial break until the trace has made one excursion downward (upward) and back to the zero line and one excursion upward (downward) and back to the zero line (one cycle of oscillation) is the *period* of the sound wave (fig. 34).

c. *Time Scale.* A relative time scale is placed on the record by two time marking styluses and a timing stamp (fig. 33). One stylus electrically

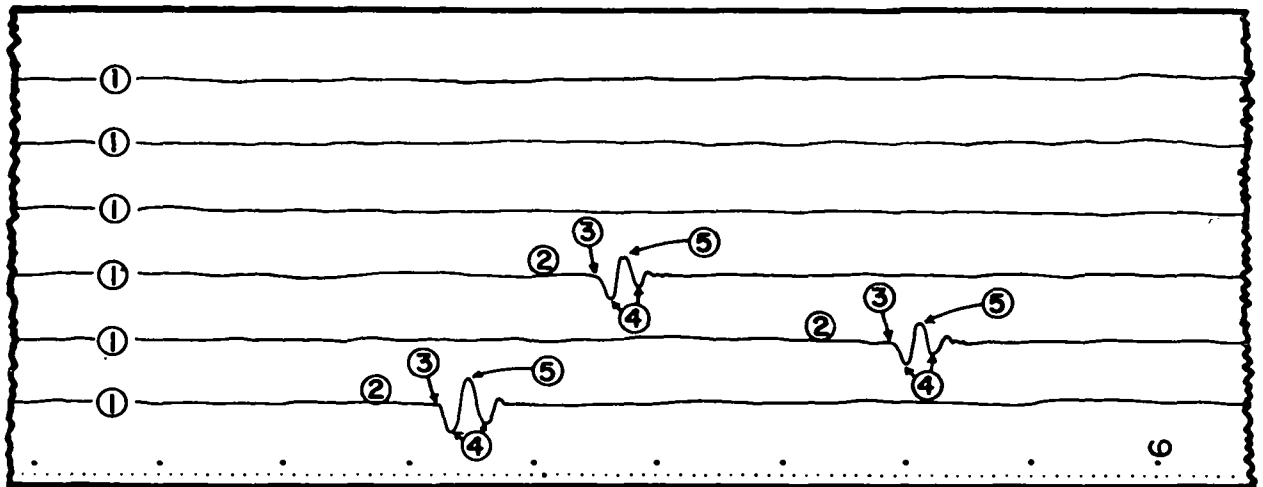
places a row of dots at intervals of 0.01 second near and parallel to the lower edge of the record, while the other stylus, synchronized with the first stylus, places a row of dots at intervals of 0.1 second just above the row of 0.01-second dots. The timing stamp, which is synchronized with the time-marking styluses, prints consecutive numbers at 1-second intervals above the time dots. This printing is done with ink, whereas all other marks are recorded electrically.

63. Pattern of Arrivals

The pattern produced by the several microphone traces on the sound ranging record by the arrival of the sound wave at the various microphones of the sound ranging base is called the *pattern of arrivals*. This pattern may be made more apparent if a smooth curve, connecting the initial breaks, is drawn on the record.

64. Typical Patterns

a. *General.* The pattern of arrivals of a given sound wave depends on the relative locations of the microphones to one another and their location with respect to the sound source. The pattern of arrivals to be expected from a given sound source can be deduced if the relative locations of the sound source and the microphones are known. Since sound platoon personnel seeking the location of a sound source will know the locations of the microphones and will have been told the approximate direction and distance to the sound source (by the observers), the pattern to be expected can be selected from the sound ranging record. To locate the sound source, sound platoon personnel must know the typical patterns produced by the various types of bases. This knowledge will aid in selecting a pattern from a sound ranging record on which more than one break occurs on one or more of the traces (para. 65a).



- ① Microphone traces.
- ② Zero lines.
- ③ Initial breaks.
- ④ Valleys.
- ⑤ Peaks.

Figure 33. A sound ranging record.

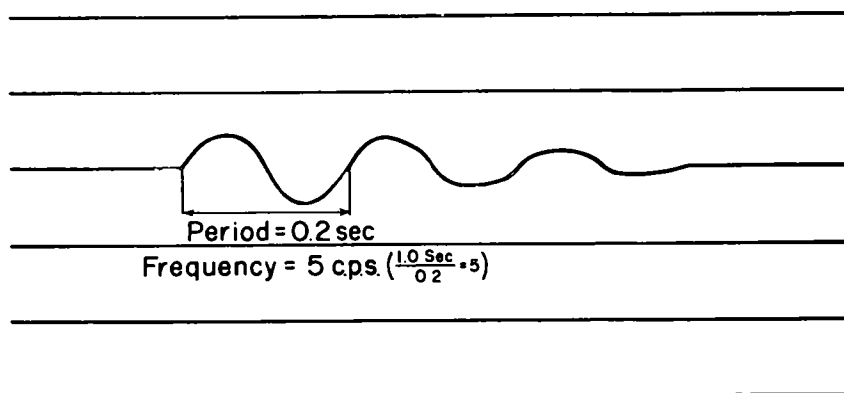


Figure 34. The period and frequency of a sound wave.

b. Regular Base Patterns.

- (1) Because the microphone positions of a regular base are an equal distance apart and have a definitely known azimuth relationship, the pattern produced will be regular in nature and will form a smooth curve. Several typical patterns produced by a straight regular base corresponding to various sound source locations are shown in figure 35. For each pattern, a smooth curve can be drawn connecting the initial breaks; in each case, the curve is concave to the right. The curve is symmetrical if the sound source is to the direct front (1-3, fig. 35), skewed in one direction with its lower branch elongated if the sound source is to the right front (5, fig. 35), and skewed in the other direction with its upper branch elongated if the sound source is to the left front (4, fig. 35). The overall length of the pattern decreases as the distance to the sound source increases (1-3, fig. 35).
- (2) Patterns produced by a curved regular base, as shown in figure 36, are generally shorter than those produced by a straight regular base. This difference in length makes it somewhat easier to recognize the pattern and visualize the curve connecting the initial breaks. Sound sources at dis-

tances beyond the center of curvature of the sound ranging base cause a pattern which is concave to the left (3, fig. 36); such a pattern cannot be produced by a straight regular base.

c. *Irregular Base Patterns.* The irregular sound ranging base, with no regularity in the spacing of the microphones, will not produce a regular pattern, and the pattern produced will not form a smooth curve. Typical patterns produced by an irregular base are shown in figure 37. The irregular pattern results in a somewhat more difficult record for the reader to interpret.

65. Record Reading

The sound ranging record is *read* or *interpreted* in three steps:

a. *Pattern Selection.* If only one sound wave producing one break on each microphone trace is recorded on the record, the selection of the proper pattern is a simple operation. When patterns from several different sound waves are recorded on the record, which is often the case, the selection of the proper pattern is more difficult. The report furnished by the observer (para. 60b) aids in the selection of the proper pattern. This report, which is recorded on the face of the record, includes the approximate azimuth and distance to the sound source; this information gives a clue to the expected arrival pattern. If the observer's report is not available, the reader will then pick out what appears

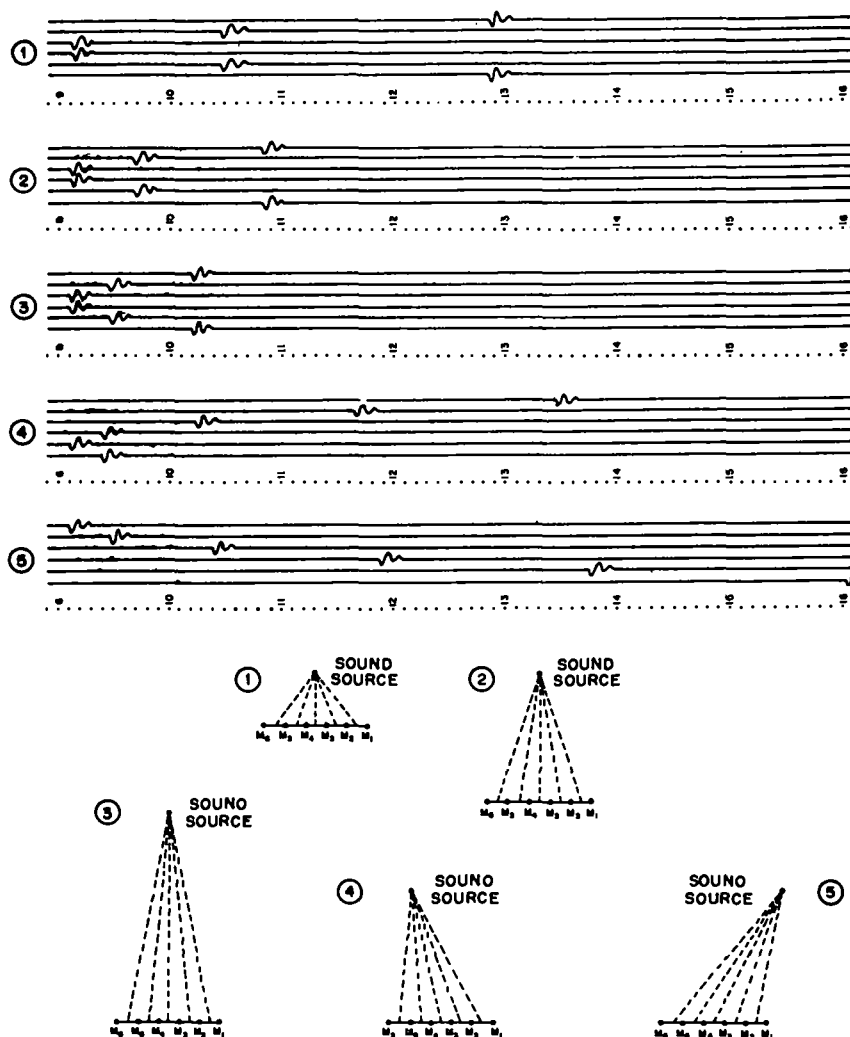


Figure 35. Typical patterns (not actual records) on a straight base record for various locations of the sound source.

to be the probable pattern, read this pattern, and have the results plotted. If a plot is obtained, the pattern can then be assumed to be a true arrival pattern. In any case, the reader must be able to mentally visualize the probable pattern and isolate it from all others.

b. Reading Point Selection. On some records, the initial break will move from the zero line so gradually that the actual point of initiation cannot be found. On other records, the point of initiation may be distorted by some other impulse arriving at the same time (wind, ballistic wave, etc.). These conditions may occur on one or more of the microphone traces. Under

such conditions, the reading point must be selected at some point other than the initial break. The important point to remember is that the same reading point must be used on all microphone traces within a given pattern. There are four acceptable reading points; they are listed in (1) through (4) below in the order of preference.

- (1) *First choice*—the initial break; that is, at the first point of departure of the trace from the zero line (1, fig. 38).
- (2) *Second choice*—the point at which the zero line is first crossed after the

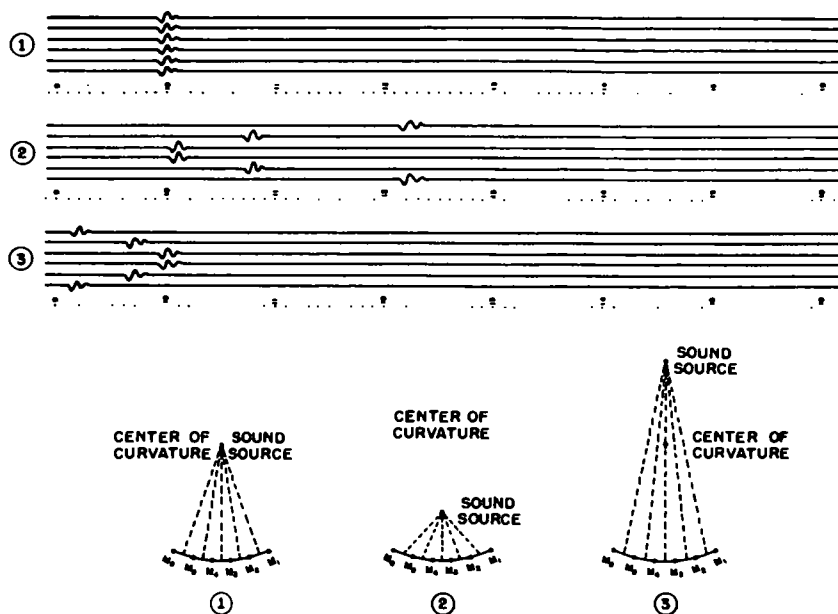


Figure 36. Typical patterns (not actual records) on a curved base record for various locations of the sound source.

initial break; that is, at the center of the cycle of oscillation (2, fig. 38).

(3) *Third choice*—at the center of the first valley; that is, the point at the center of the first half of the cycle of oscillation (3, fig. 38).

(4) *Fourth choice*—at the center of the first peak (crest); that is, the point at the center of the second half of the cycle of oscillation (4, fig. 38).

c. Arrival Time Determination. After the pattern and reading point have been determined, the sound ranging record is placed in the record reading tool, with the end that first emerged from the sound recording set always to the left (the time scale will always be at the bottom of the record). To determine the arrival time of the sound wave at each reading point—

(1) Line up the vertical hairline of the reading tool with the reading point on the microphone trace (*b* above), making certain that the lower edge of the record is firmly in contact with the bottom of the slot in the reading tool along the entire length of the tool.

(2) Read the time on the time scale where the vertical hairline of the reading tool intersects the time scale. The arrival time is read directly to the nearest 0.01 second and, by interpolation between the 0.01-second dots, to the nearest 0.001 second. Because of the errors inherent in visual interpolation, the determined arrival time will be accurate to within 0.002 second to 0.003 second.

(3) Employing the procedures in (1) and (2) above, read the arrival times (in seconds) for the pattern shown in figure 39 as follows:

M_1 : 3.072.
 M_2 : 2.002.
 M_3 : 1.451.
 M_4 : 1.462.
 M_5 : 2.033.
 M_6 : 3.135.

66. Difficult Records

Records containing breaks for only one sound source which have been recorded under optimum conditions will be similar to the record

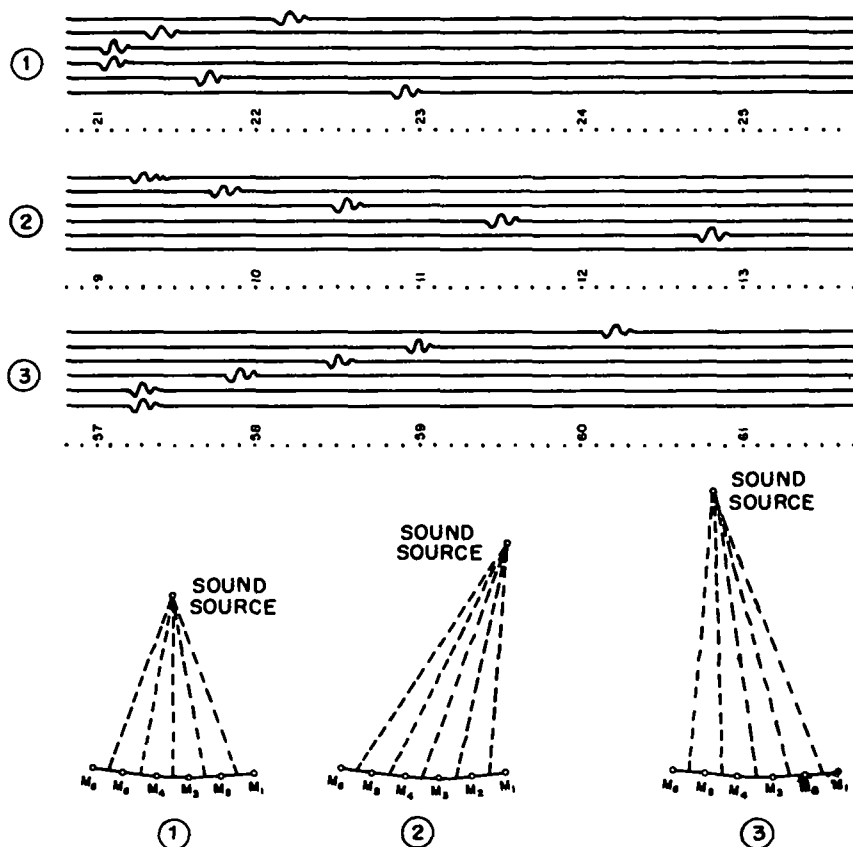


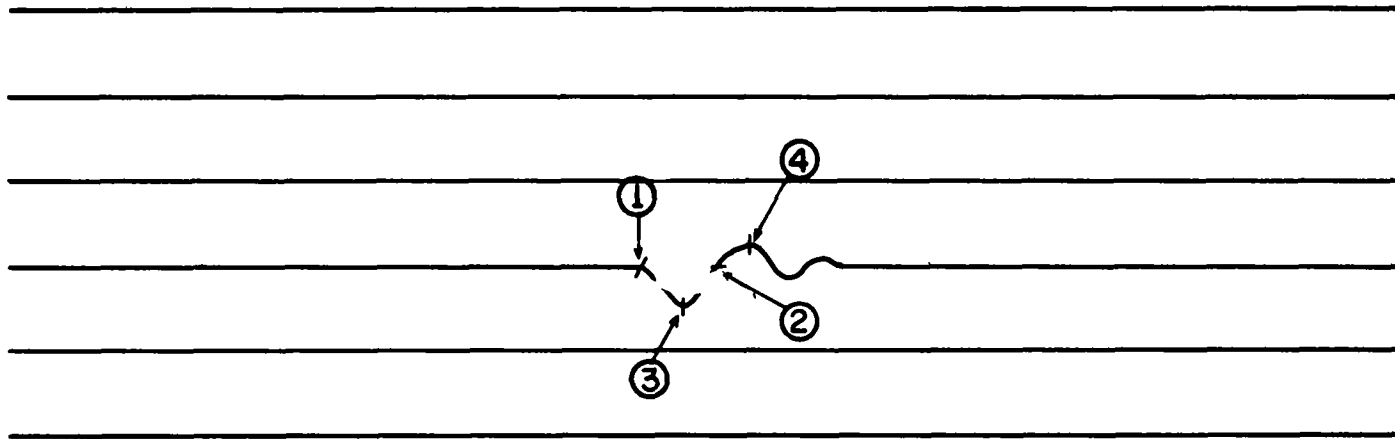
Figure 37. Typical patterns (not actual records) on an irregular base record for various locations of the sound source.

shown in figure 39; however, most records will not be obtained under optimum conditions. As a result, the record reader must be able to interpret records which have been obtained under any conditions. Much practice is required in the evaluation of difficult records; that is, records which are obtained under other than optimum conditions. Some of the many factors which may be responsible for making a record difficult to interpret are as shown in *a* through *g* below.

a. Indistinct Breaks. Indistinct breaks are usually caused by very low frequency sounds or low sound wave energy as it arrives at the microphone position. Breaks representing sound waves from wind or other disturbances picked up by the microphone and superimposed on the microphone trace will intensify the problem of indistinct breaks. Whenever possible,

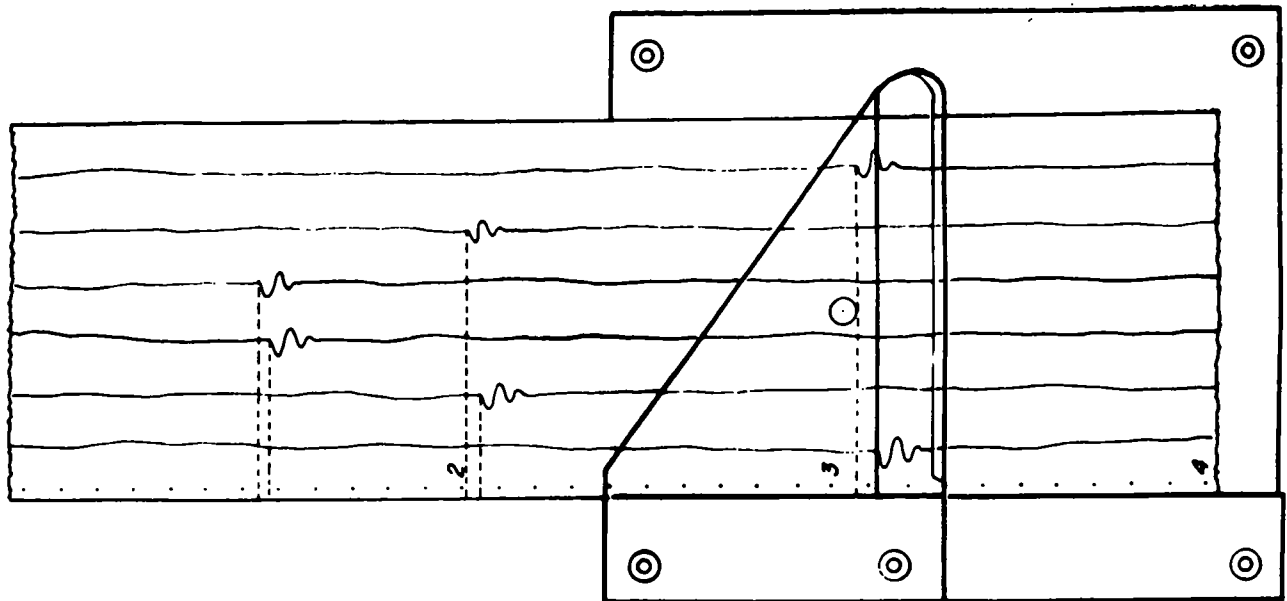
this difficulty is overcome by a judicious choice of the reading point on the traces. Care must be taken to choose the same reading point on all traces for each pattern (para. 65b).

b. Ballistic Waves. Since the sound recording set will record ballistic waves, ballistic wave breaks might be confused with the breaks caused by the gun wave of a weapon firing. Special use is made of the recordings of ballistic waves (ch. 15), but care must be exercised to see that a recorded ballistic wave is not interpreted as part of the pattern of a gun wave of a weapon; this is particularly true of an irregular base when no regular pattern will be seen. The ballistic wave is of somewhat higher frequency than the gun wave of a weapon and, in practically all instances, can be positively identified (fig. 40). When the energy of the gun wave has



- ① INITIAL BREAK, FIRST CHOICE, READ WHENEVER POSSIBLE.
- ② ZERO LINE, SECOND CHOICE, READ WHEN INITIAL BREAK IS OBSCURED ON ONE OR MORE TRACES.
- ③ FIRST VALLEY, THIRD CHOICE, READ WHEN INITIAL BREAK AND ZERO LINE ARE OBSCURED ON ONE OR MORE TRACES.
- ④ FIRST PEAK, FOURTH CHOICE, READ WHEN POINTS 1, 2, AND 3 ARE OBSCURED ON ONE OR MORE TRACES.

Figure 38. Reading point selection.



(Not to scale)

Figure 39. Use of the record reading tool.

been dissipated over a long distance, the ballistic wave could have greater energy at the time of recording. During these recordings, the ballistic wave will be superimposed on the gun wave. Only great care in the analysis of the record will separate the true gun wave from the ballistic wave under such conditions.

c. Wind Disturbances. Wind creates pressure waves which cause a wavering microphone trace. The pressure waves may conceal weak gun waves or make it difficult to distinguish stronger gun waves if they are superimposed on them on the record (fig. 41). Pressure waves of sufficiently high winds will conceal gun waves of very strong energy. In this case, the only remedial action which can be taken is to vary the sensitivity of the microphone by the controls on the sound recording set (for a description of this procedure, see TM 11-2568) or to shield the microphone installations as discussed in paragraph 52. Wind speeds of 30 to 35 miles per hour and above usually create conditions which are beyond elimination by any known means.

d. Shellburst Waves. The sound recording set will record the sound wave impulses of shellbursts. Shellburst waves have approximately

the same effect as ballistic waves on the interpretation of the record. However, since the shellburst waves are nearly the same frequency as the gun waves, they will be even more difficult to isolate from gun wave breaks than are the ballistic waves (see fig. 40). Shellburst waves have much less energy than gun waves but cause more interference when the shellburst occurs close to the base. If the shellburst occurs at normal weapon distances, the shellburst wave, if recorded, cannot be mistaken for a gun wave; if the shellburst occurs near the base, its high frequency will reveal that its wave is not a gun wave.

e. Multiple Arrivals. Multiple arrivals of the same sound wave at a microphone position may cause breaks to appear on the sound ranging record which obscure the true break. Multiple arrivals may be caused by any of the following:

- (1) A sound wave reflected by a large hill or building.
- (2) A sound wave diffracted around a large hill or building.
- (3) A sound wave refracted back to earth by a temperature inversion and arriving at the microphone over two separate paths.

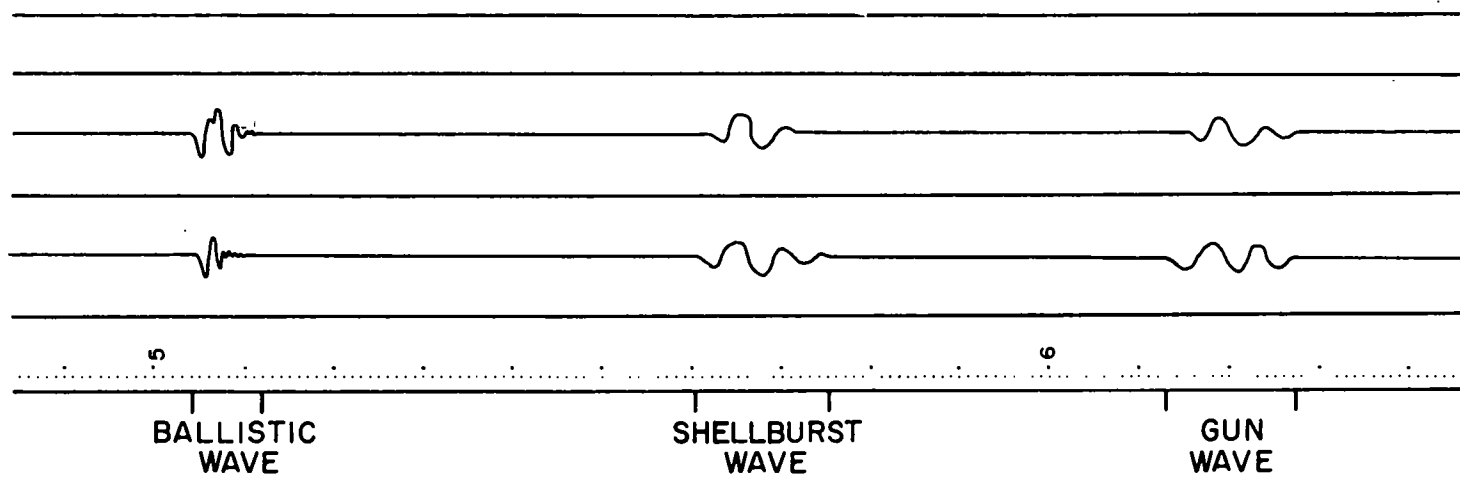
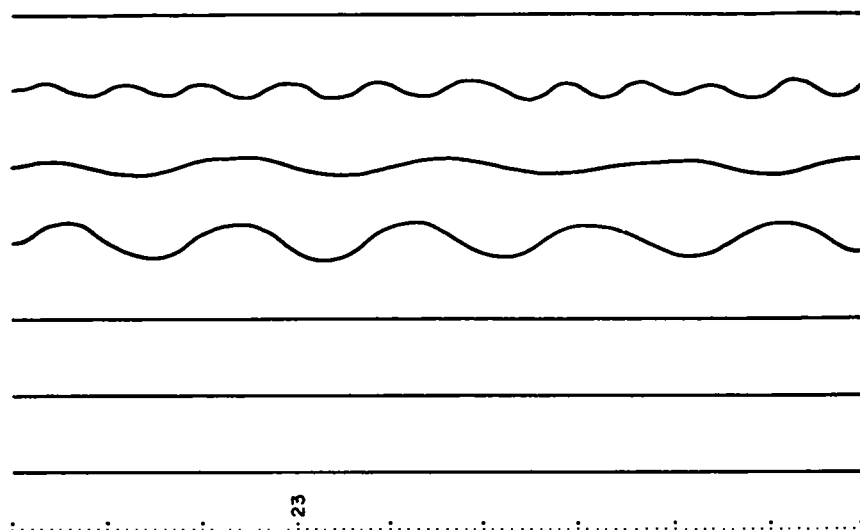


Figure 40. Ballistic, shellburst, and gun waves.



Amplitude of wind-caused wavering is related to the wind speed and the microphone sensitivity.

Figure 41. Wind effect on microphone traces.

f. Multiple Sources. When large numbers of friendly or enemy weapons are firing at the same time, large numbers of initial breaks will appear on the microphone traces. Many initial breaks will be superimposed on others, resulting in so many patterns that the record will be totally confused and true patterns will be extremely difficult to select. Records obtained under these conditions are the most difficult of all records to effectively interpret, since it will be possible in many cases to select false patterns resulting in the selection of false locations.

g. Friendly Fire. Many sound ranging records will contain patterns not only of hostile weapons but also of friendly weapons. The sound ranging base is so positioned that most sounds from the front are from hostile weapons and most sounds from the rear are from friendly weapons. The straight regular base record will plot equally well sounds from the front and from the rear; on the record, the patterns from both front and rear sound sources will appear to be the same. With such a base, a microphone installed 0.1 second in front of or to the rear of one of the normal microphones of the base will indicate from which direction the sound came and aid materially in discerning the friendly weapon patterns on the record.

67. Reading Difficult Records

When difficult records caused by one of the conditions listed in paragraph 66, or by a combination of the conditions, the record reader will often work directly with the plotter (para. 102a and b). A pattern is selected and the breaks are read and plotted. If some of the breaks in the pattern selected seem to be in error, the expected point of the break can be determined by reading the time intervals from the plots of the other traces. Close coordination is required between the record reader and the preliminary plotter to properly use this procedure.

68. Caliber Estimation

a. The period and frequency of a sound wave (fig. 34) of a weapon depends on the caliber of the weapon. As shown in figure 42, the larger the caliber of the weapon, the lower will be the frequency of the sound wave generated by that weapon. As a result, the period of the sound wave of larger caliber weapons will be longer. For example, in figure 42, the gun (muzzle) wave of a 100-mm howitzer-type weapon has a frequency of approximately 20.5 cycles per second, whereas the gun (muzzle) wave of a 200-mm howitzer-type weapon has a frequency

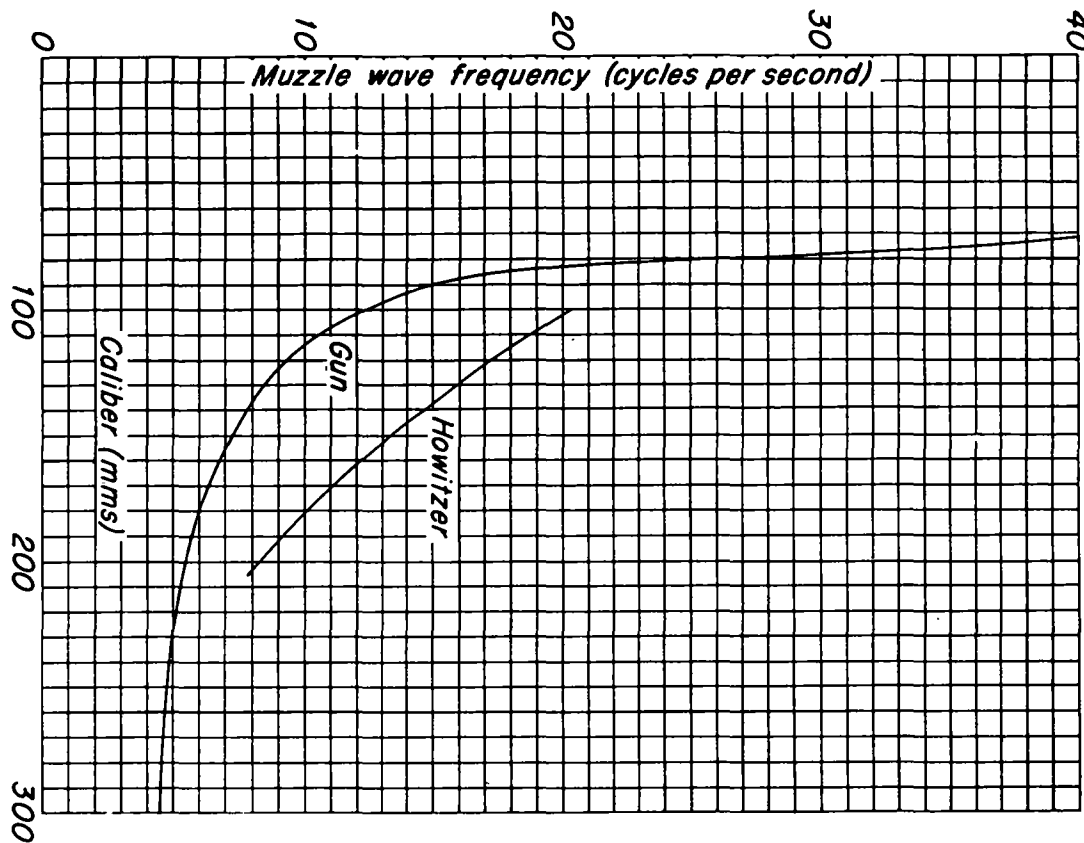


Figure 42. Gun and howitzer muzzle wave frequency curves.

of approximately 8 cycles per second. Therefore, the period of the gun wave of the 200-mm weapon (approximately the 8-inch howitzer) is more than double that of the 100-mm weapon (approximating the 105-mm howitzer). It can be seen that the measurement of the recorded period or frequency, even though only approximate, is an aid in estimating the caliber of the weapon. Only smooth, typical waves with no obvious distortion should be used for this purpose. Results will be reasonably accurate only if the recording equipment is capable of following the sound pressure variations. The recorded period will not be the same for all weapons of the same caliber and type but will vary with—

- (1) The characteristics of the weapon, such as its tube length, powder charge, and tube conditions.
- (2) The weather conditions through which the sound wave passes.
- (3) The distance from the weapon to the sound ranging microphones.

b. Data should be collected for those weapons expected to be encountered in combat. Specific weapons cannot be positively identified by this method unless there are other indications as to the weapon type, such as shell or rotating band fragments, or unless only a few types are in use on a given front. Artillery weapons can

usually be classified as light, medium, or heavy by the use of this method.

c. The observer's report is another aid in the estimation of the caliber and type of weapon. If the approximate location of the shellburst is reported or if the shellburst sound wave is recorded and plotted and the firing range of the weapon is determined, the firing range may give an indication of the caliber. Even though the shellburst is not located, the distance from the plotted location of the weapon to the sound ranging base and the forward edge of the battle area will usually indicate whether the weapon is a light, medium, or heavy weapon. It should

be emphasized that the result of these operations will be only an estimation of the caliber and type of weapon unless additional indications are available.

d. If firing tables of enemy artillery weapons are available to sound platoon personnel, these tables can be used as a means of determining the caliber and type of weapon firing. The firing table technique can be used only if the gun wave and the shellburst wave are recorded on the same sound ranging record. From such a recording, the weapon and shellburst locations are determined in the normal manner. These two locations are used to determine the sound

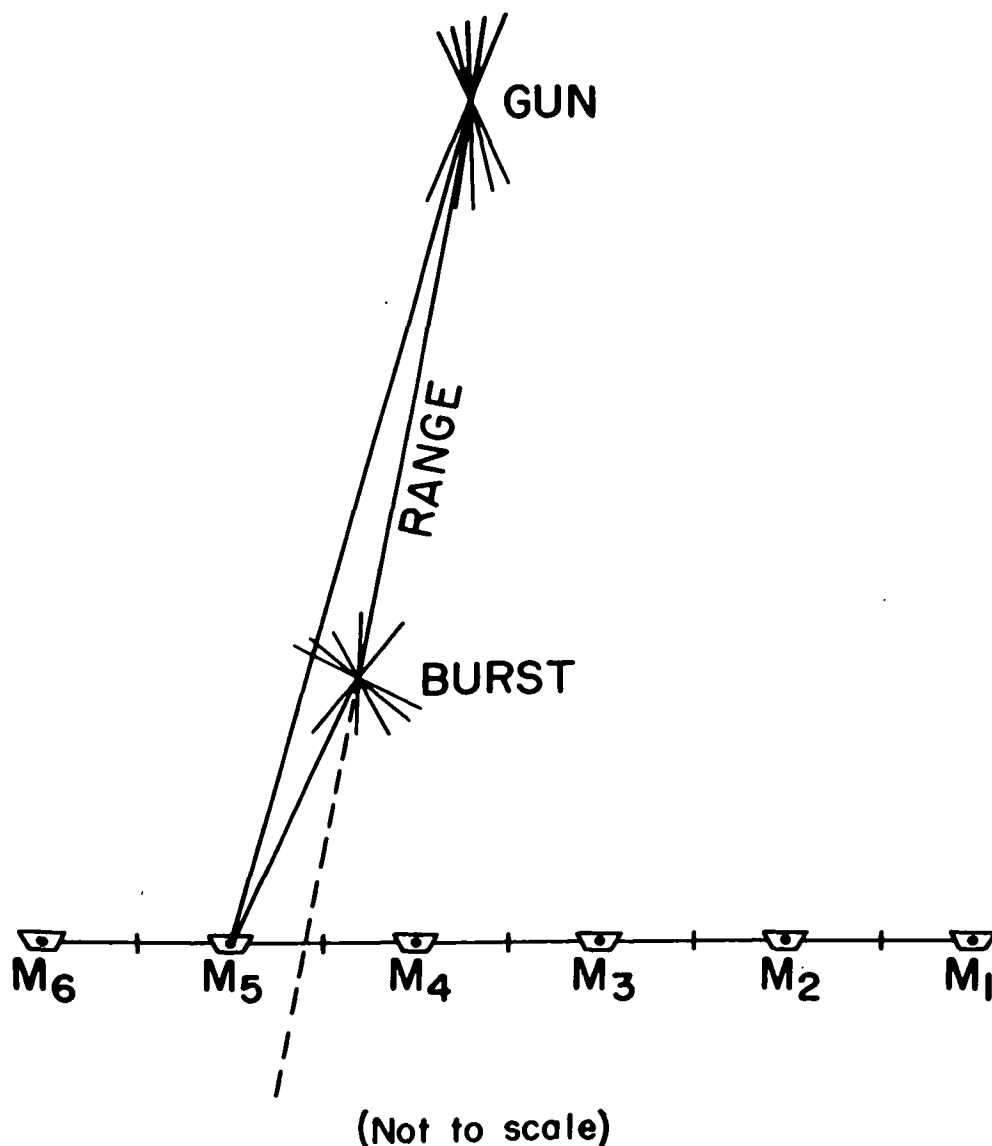


Figure 43. Plot of gun position and shellburst location.

Range gun-burst	5,953 M
Range M ₅ - gun	11,520 M
Time of travel ($\frac{11520}{337.6}$)	34.123 sec
Range M ₅ - burst	5,565 M
Time of travel ($\frac{5565}{337.6}$)	16.484 sec
Record reading - gun	0.148 sec
Record reading - shell	2.676 sec
Difference in arrival times	+ 2.528 sec
Difference in travel times	17.639 sec
Time of flight	20.167 sec

Figure 44. Computations for determining a projectile's time of flight.

travel time from the weapon and the shellburst to one microphone of the sound ranging base. To compute the sound travel time—

- (1) On the plotting chart, measure the distance from the weapon location to the reference microphone (usually the microphone nearest the line of fire or its prolongation) (fig. 43).
- (2) Convert the measured distance into time by dividing by the speed of sound, 337.6 meters (fig. 44). No corrections are applied since the overall accuracy of the method does not warrant such corrections.
- (3) Subtract the distance in time of the shellburst location from the distance in time of the weapon location to obtain the difference in time distance (fig. 44).

- (4) Compute the projectile's time of flight by adding (subtracting) the difference in arrival time of the shellburst wave and the gun wave at the reference microphone (read from the sound ranging record) to (from) the difference in time distance obtained in (3) above (fig. 44).

Note. Time of flight can usually be determined from a single record to within a few tenths of a second of the true time of flight as recorded in the firing tables. The computed time of flight together with the range measured from the hostile weapon to the shellburst location are used to enter the available firing tables to find the weapon having a range and time of flight agreeing with those computed in (1) through (4) above. If a number of different types of howitzers are in use by the enemy, the method described must be used with caution since the large number of charges available for each weapon produce nearly similar times of flight for different weapons.

CHAPTER 11

PLOTTING DEVICES AND CHARTS

Section I. PLOTTING DEVICES AND TECHNIQUES

69. General

As described in paragraph 18, a sound source location is determined by the intersection of lines drawn from several pairs of microphones over which the sound wave passed. The direction of the lines drawn from each pair of microphones is computed by using the formula $\sin \theta = T/S$. For the purpose of artillery sound ranging, this formula is solved graphically by the use of various plotting devices. Sound ranging plotting devices are so graduated that when the determined time interval is laid off on the plotting chart by means of the plotting device, the correct angle θ for that particular time interval and subbase length is produced.

70. The 4-Second Subbase Plotting Fan

a. General. Figure 45 illustrates the 4-second (1,350.4 meters) subbase plotting fan. The 4-second subbase plotting fan can be used only with 4-second subbases unless the time intervals are converted to a 4-second equivalent.

b. Description. The 4-second subbase plotting fan, made of transparent plastic, is composed of five scales and two templates.

- (1) The two time scales on the curved outer edge of the fan are used to produce the angle θ for any given time interval determined by use of a 4-second subbase. The time scales are graduated in 0.01-second increments and are numbered at 0.1-second intervals; they can be interpolated to the nearest 0.001 second. The outer time scale; it is graduated from 0 seconds on the right edge of the fan to 3.460 seconds on the left edge. The inner time scale, which is numbered in red, is the

minus time interval scale; it is graduated from 0 seconds on the left edge of the fan to 3.460 seconds on the right edge. The plus and minus time scales are further identified by appropriate signs in small circles on each edge of the fan.

- (2) Below the time scales are two angular scales; one scale is graduated in degrees, the other is graduated in 10-minute increments and is numbered at 5° intervals. The mil scale is graduated in 10-mil increments and is numbered at 100-mil intervals.
- (3) The range scale is on the right edge of the fan; it is graduated in 50-yard increments and is numbered at 1,000 yard intervals from 0 to 14,000 yards to a scale of 1:25,000. The range scale is used to measure distances on the sound ranging plotting chart.
- (4) A series of five small holes is located immediately below the time scales. The holes are used as templates for drawing the midpoints of a 4-second subbase of a straight regular base at a scale of 1:25,000. There are three more holes in the lower portion of the fan; these are used *only* in the preparation of a preliminary plotting chart as discussed in paragraph 75.

c. Plotting Time Intervals. To plot a time interval having a plus sign, place the vertex of the fan at the subbase midpoint, rotate the fan until the determined time interval on the black scale is over the normal for this midpoint, and draw a ray along the *right* edge of the fan (rays drawn for plus time intervals are drawn

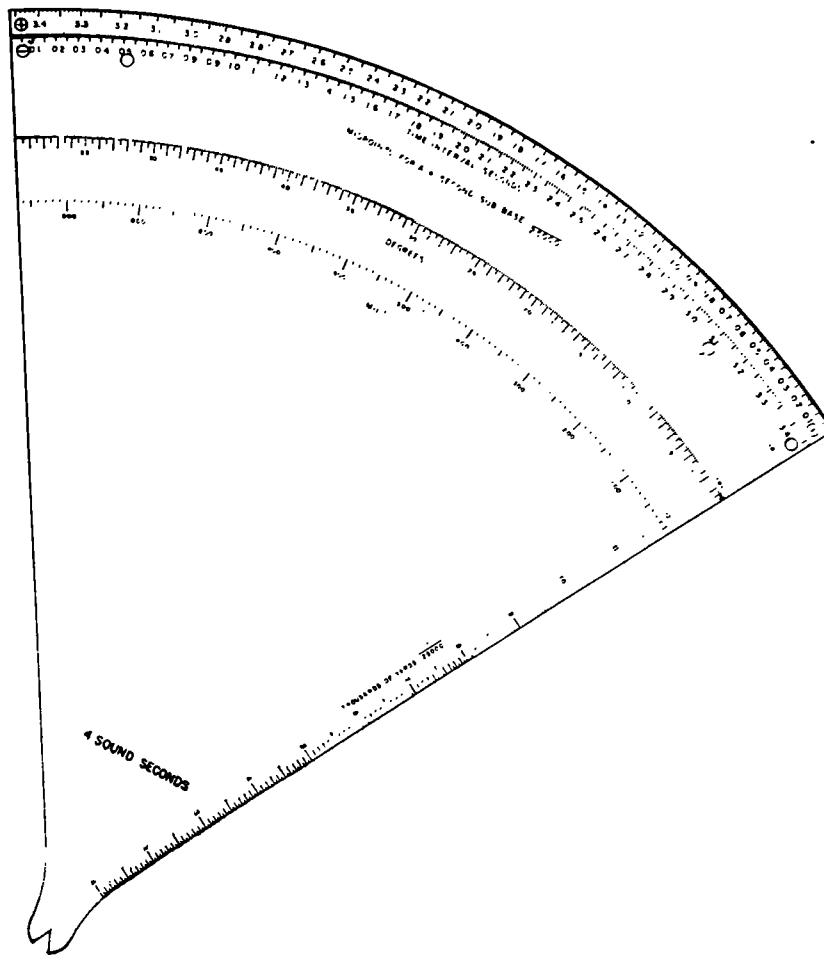


Figure 45. The 4-second subbase plotting fan.

along the right edge of the fan). To plot a time interval having a minus sign, manipulate the fan as above until the determined time interval on the red scale is over the normal for the proper midpoint and draw a ray along the *left* edge of the fan (rays for minus time intervals are drawn along the left edge of the fan). When the procedures described above are followed, the angle θ for a given time interval is graphically plotted.

71. The All-Subbase Plotting Fan

a. General. Figure 46 illustrates an all-subbase (usable with any subbase from 550 to 1,910 meters in length) plotting fan.

Note. The scale graduations on an actual fan are smaller than shown in figure 46. The fan illustrated can be used with either preliminary or final plotting charts.

b. Description. The all-subbase plotting fan, made of transparent plastic, is composed of five scales and two templates.

- (1) The two time scales on the curved outer edge of the fan are used to produce the angle θ for any given time interval determined by use of a 2-second subbase. The time scales are graduated, numbered, and identified in the same manner as those on the 4-second subbase fan (para. 70 *b*). When the all-subbase plotting fan is used with 2-second subbases, the use of the time scales is identical with that of the time scales on the 4-second subbase plotting fan (para. 70 *c*).
- (2) A series of parallel lines, known as time lines, is scribed on the center por-

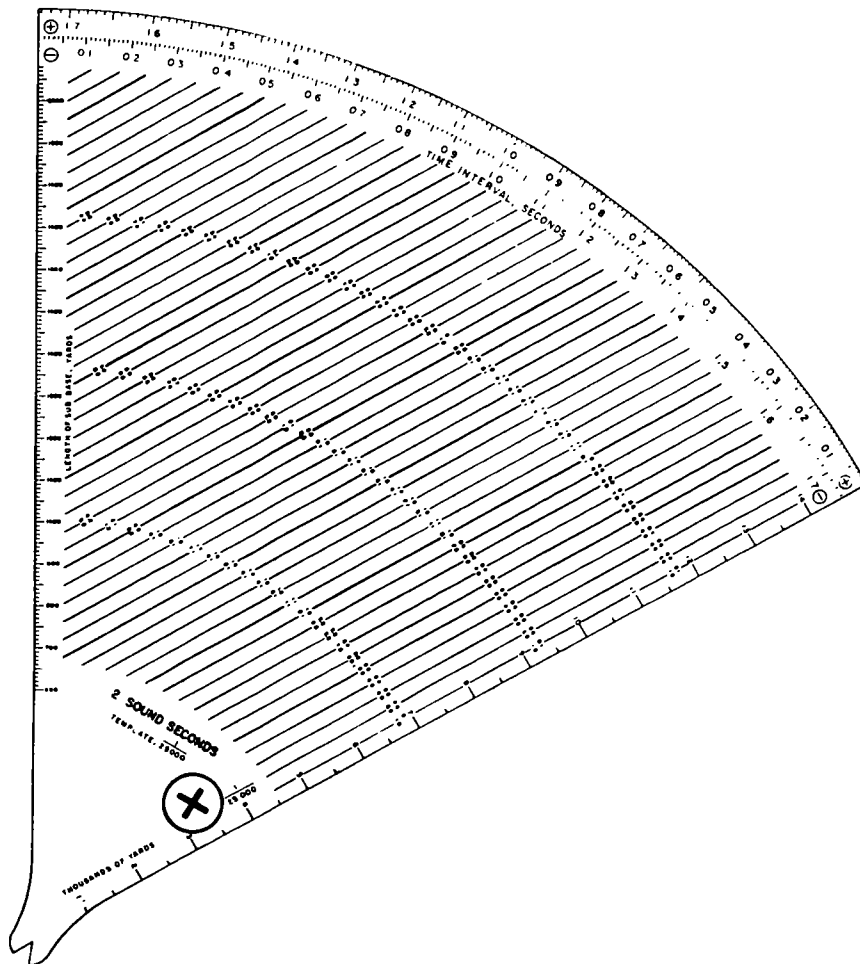
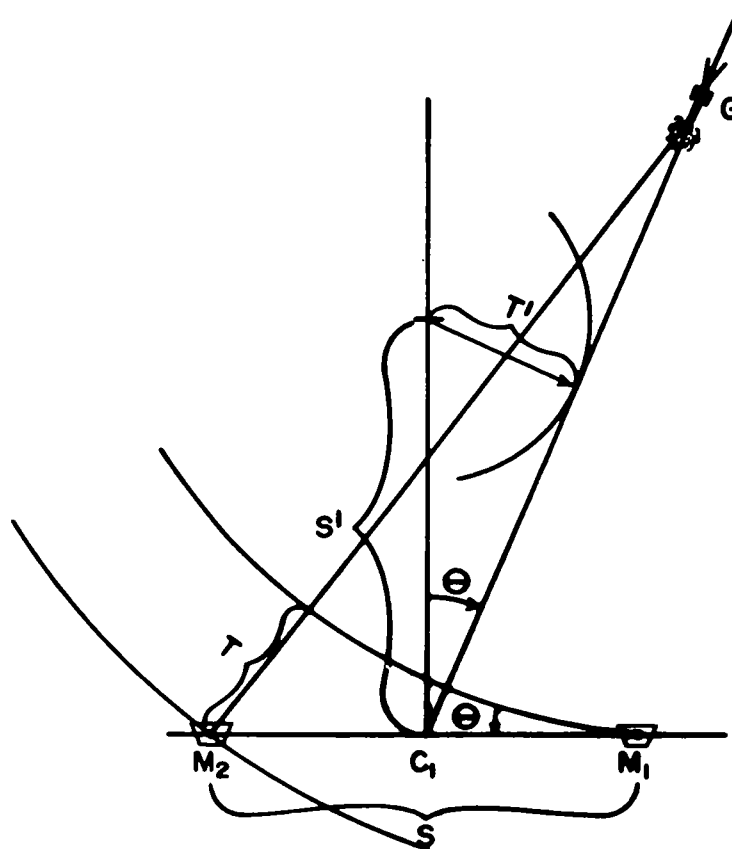


Figure 46. The all-subbase plotting fan.



T = TIME INTERVAL $M_1 - M_2$

S = SUBBASE $M_1 - M_2$

S' = SUBBASE LENGTH PLOTTED ALONG THE PERPENDICULAR BISECTOR OF SUBBASE $M_1 - M_2$

T' = ARC EQUAL IN RADIUS TO TIME INTERVAL $M_1 - M_2$ SWUNG FROM END OF SUBBASE PLOTTED ALONG NORMAL

A LINE DRAWN FROM C_1 TANGENT TO ARC SWUNG WITH RADIUS EQUAL TO T REPRODUCES ANGLE θ AND FORMS LINE $C_1 - G$ THROUGH OR VERY NEAR THE SOUND SOURCE

Figure 47. Construction of time lines of an all-subbase plotting fan.

tion of the all-subbase fan. The time lines are used to graphically solve for angle θ for time intervals determined by use of any subbase length from 550 to 1,910 meters. Heavy black time lines are scribed at 0.1-second intervals, whereas lighter black time lines are scribed at 0.02-second intervals. Figure 47 illustrates the manner of con-

struction of the time lines. To use the fan for plotting a plus time interval, position the fan so that the plus sign is visible in the large white circle on the lower portion of the fan and read the time interval from the black numbers. To use the fan for plotting a minus time interval, position the fan so that the minus sign is visible in the

large white circle on the lower portion of the fan and read the time interval from the red numbers.

- (3) If the fan is positioned so that the plus sign is visible, the subbase length scale is on the left edge of the fan. This scale is graduated in 10-meter increments from 550 to 1,910 meters and is numbered at 100-meter intervals. The subbase length scale is usable only in conjunction with the time scales scribed on the center of the fan (to mark the subbase length along the perpendicular bisector of the subbase); it cannot be used to measure any distances other than these subbase lengths.
- (4) If the fan is positioned so that the plus sign is visible, the range scale is on the right edge of the fan. This scale is graduated in yards from 1,000 to 14,000 yards at a scale of 1:25,000. The range scale is used to measure distances on the plotting chart.
- (5) A series of five small holes is located immediately below the 2-second time scales. These holes are used as templates for drawing the midpoints of a 2-second subbase of a straight regular base on a 1:25,000 scale plotting chart. Five other holes are located in the lower portion of the fan. These holes are used only in the preparation of preliminary plotting charts as discussed in paragraph 75.

c. Plotting Time Intervals.

- (1) Time intervals from a 2-second subbase of a straight regular base are plotted with the time scales on the all-subbase fan in exactly the same manner as those determined by use of a 4-second subbase of a straight regular base (para. 70c).
- (2) When the fan is used to plot time intervals of an irregular base, opposite sides of the fan are used for plus and minus time intervals. To plot plus time intervals, position the fan so that the plus sign is showing in the large white circle, read the black time line num-

bers, and draw a ray along the right edge of the fan. To plot minus time intervals, turn the fan over so that the minus sign is showing in the large white circle, read the red time line numbers, and draw a ray along the left edge of the fan. To plot a time interval, place the vertex of the fan at the subbase midpoint and rotate the fan until the determined time interval on the time line scale is over the index point marked on the normal as the subbase length. Since the time lines are 0.02 second apart, carefully interpolate between the lines to obtain the correct reading. After the fan is positioned as above, draw a ray along the right (left) edge of the fan (depending on whether the time interval has a plus sign or a minus sign).

72. The Special All-Subbase Plotting Fan

a. General. Figure 48 illustrates a special all-subbase sound ranging plotting fan.

Note. The scale graduations on an actual fan are smaller than shown in figure 48. The fan illustrated can be used with either preliminary or final plotting charts.

b. Description. The special all-subbase plotting fan, made of transparent plastic, is composed of six scales.

- (1) The two time scales which produced the angle θ for any given time interval determined by use of a 4-second subbase are on the curved outer edge of the fan. The time scales are numbered and graduated in the same manner as the time scales on the 4-second subbase fan (para. 70 b) except that the plus time scale is on one side of the fan and the minus time scale is on the reverse side of the fan. The same scale graduations are read for both plus and minus time intervals, but the scale numbering is correct only when the proper side of the fan is used.
- (2) A series of parallel time lines is scribed on the center portion of the fan. The graduation and numbering of these lines are the same as those on the all-

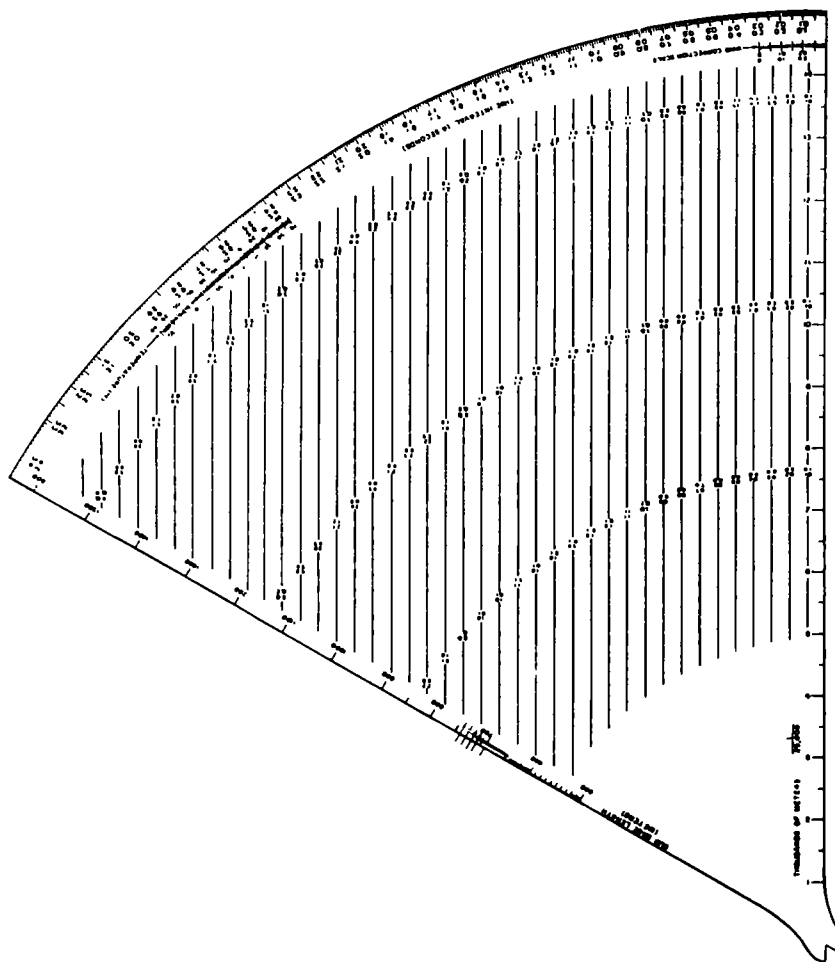


Figure 48. The special all-subbase plotting fan.

subbase plotting fan (para. 71 b) except that the smallest graduation is 0.01 second. The time lines are used in the same manner as those on the all-subbase plotting fan (para. 71b).

- (3) When the fan is positioned so that 0 seconds on the time scale appears on the right edge of the fan (as for plus time interval readings), the subbase length scale is on the left edge of the fan. The subbase length scale is graduated in 2-meter increments from 500 to 1,600 meters and is numbered at 100-meter intervals. The construction and use of this scale are the same as those of the corresponding scale on the all subbase fan (para. 71 b).

- (4) When the fan is positioned as in (3) above, the range scale is on the right edge of the fan. The range scale is graduated in 500-meter increments from 1,000 to 15,000 meters at a scale of 1:25,000. The range scale is used to measure distances on the plotting chart.

- (5) When the fan is positioned as in (3) above, the temperature scale is on the curved edge of the fan between the outer time scale and the time lines on the center of the fan. The temperature scale is graduated in degrees Fahrenheit from -70° to $+140^{\circ}$. Use of this scale in the graphical application of

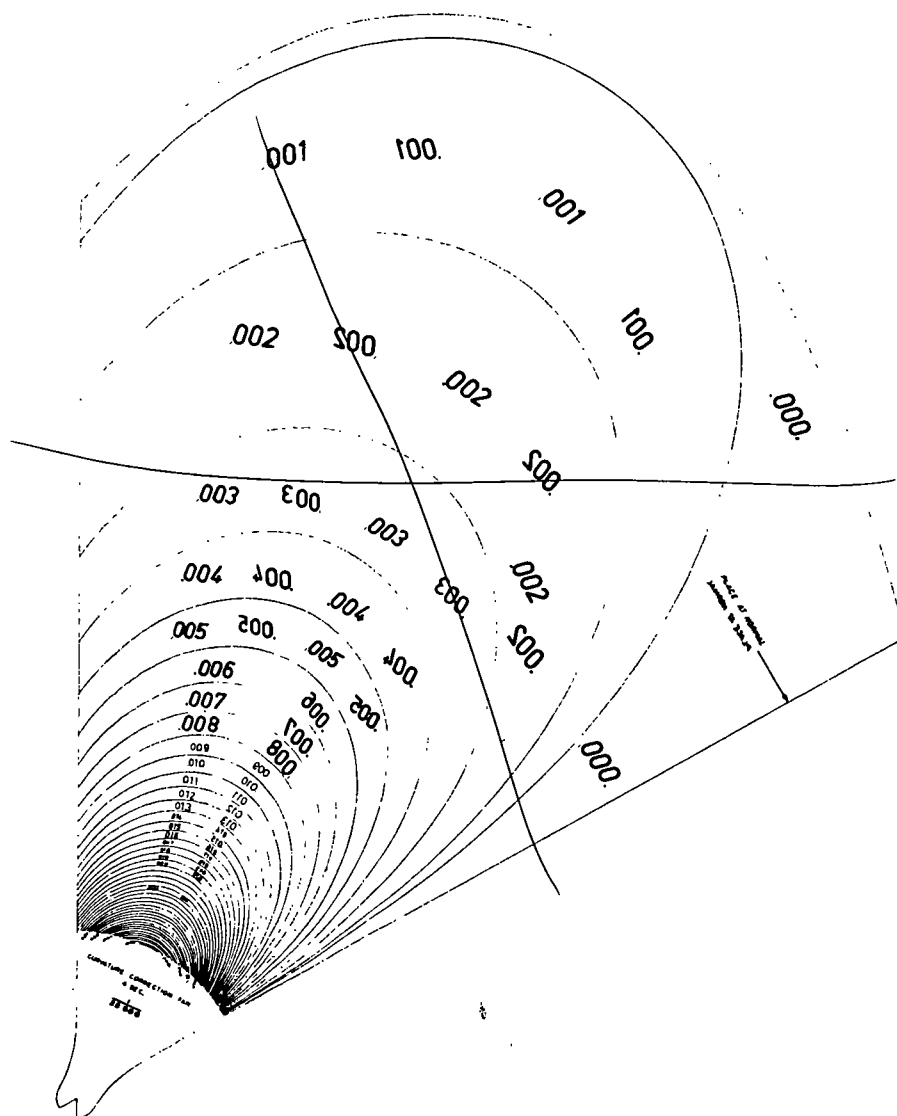


Figure 49. A 4-second subbase curvature correction template.

temperature corrections is discussed in paragraph 75d(1).

- (6) When the fan is positioned as in (3) above, a reproduction of a segment of the outer time scale is on the curved edge of the fan between the outer time scale and the time lines on the center of the fan. The segment is graduated from 0.3 second on the right edge of the fan to 0 seconds toward the left. This is a special time interval scale; its use is discussed in paragraph 75d(5).

c. Plotting Time Intervals.

- (1) To plot time intervals obtained from a 4-second subbase of a straight regular base, follow the procedures used with the 4-second subbase fan (para. 70c). Use the appropriate side of the fan for plus time intervals and the reverse side for minus time intervals.
- (2) To plot time intervals obtained from other than 4-second subbases, use the time lines on the center portion of the fan in the same manner as you use the time lines on the all-subbase fan (para. 71c).

73. Curvature Correction Template

a. General. Figure 49 illustrates a 4-second subbase curvature correction template for sound plotting. The template is used only for the determination of the curvature correction. It may be issued as a separate template or as a correction scale on the 4-second subbase plotting fan.

b. Description. When issued as a separate item of equipment, the curvature correction template is composed of only the correction lines; when it is a part of the 4-second subbase plotting fan (para. 70), the correction lines are superimposed on the fan. The correction lines of the template are black, whereas the correction numbers are both black and red. The black numbers indicate plus corrections and the red numbers indicate minus corrections. The value of the correction is read from the template according to the position of the plot within a particular correction sector of the template.

c. Determining Corrections. To determine corrections for plots to the *right* of the normal (plus time intervals), place the edge of the template bearing black lettered instructions on the normal line, and read the correction numbered in black for the correction sector in which the plot is made. To determine corrections for plots to the *left* of the normal (minus time intervals), turn the fan over and place the edge of the template bearing red lettered instructions on the normal line and read the correction numbered in red for the correction sector in which the plot is made. The curvature correction so determined takes the same sign as the weather-corrected time interval for the appropriate subbase.

d. Plotting Charts. When the curvature correction template is used, the plotting chart is set up in the following manner: If the subbases are

common in length and the base is straight, the midpoints are plotted 1,350.4 meters (4 seconds) apart at a scale of 1:25,000; if the base is straight and one or more subbases are not common in length, the midpoints of noncommon length subbases are plotted at proportional distances from the other midpoints. For example, subbase 1 of a six microphone straight base is 1,500 meters long; the remaining subbases are 1,200 meters long. The midpoints of the 1,200-meter subbases are plotted as described above.

Microphone 2 is plotted $675.2 \frac{(1,350.4)}{2}$ meters from midpoint 2. Midpoint 1 is then plotted 843.6 meters (one-half of $\left(\frac{1,500}{1,200}\right) \times 1,350.4$) from microphone 2. Normals are constructed in the usual manner. If the base is not straight, the midpoints are plotted as described in paragraph 76a(1)(b), except that the distances are determined as described above.

e. Special Applications. If the subbases are not 1,350.4 meters in length, the resulting plot is not true to scale; distances from the midpoints of such subbases have been converted to distances which would exist for 4-second subbases. Thus, the curvature correction may be determined by using the 4-second curvature template. The curvature correction for a noncommon length subbase is determined by shifting the center of the plot along the ray from this subbase by the ratio of a common length subbase to the noncommon length subbase. For example, if the common length subbase were 1,200 meters in length, the center of the plot for a 1,500-meter subbase would be shifted to a point four-fifths (1200/1500) the distance from the midpoint of the 1,500-meter subbase along its ray to the plot of the sound source. The curvature correction for this subbase would then be read directly on the template where this point appears.

Section II. PLOTTING CHARTS

74. General

Sound ranging locations may be plotted on grid sheets, ungridded sheets, maps, photomaps, photographs, or flash ranging plotting boards. The materials available and the results desired

will determine whether both preliminary and final charts or only a final chart will be used. Generally, the preliminary chart will be an ungridded chart, whereas the final chart will be a gridded chart.

75. Preliminary Plotting Charts

a. General. Preliminary charts, usually ungridded, are used to plot weather-corrected time intervals in order to obtain a preliminary distance to the target so that the curvature correction can be determined. A preliminary chart may also be used for making relative locations, to conduct sound-on-sound adjustments, and to test-plot uncorrected time intervals to determine whether the record reader has read the proper breaks on the sound ranging record. The preparation of the preliminary chart differs in its final steps for each of the three types of plotting fans; however, in the initial steps (plotting midpoints and constructing normals), the same procedures are followed. If a gridded preliminary chart is to be used, the chart is prepared in the same manner as a final plotting chart (para. 76). Use of a gridded plotting chart will greatly facilitate the plotting of the midpoints of an irregularly alined base. An ungridded plotting chart is constructed in the following manner:

- (1) *Plotting midpoints.* The midpoints should be plotted near the center of the bottom edge of the plotting chart to afford a maximum area in which to plot sound source locations.
- (a) To plot midpoints for a straight regular (or straight irregular) base, draw a straight line on the chart where it is desired to plot the midpoints. Then, after picking any point on this line as one midpoint, plot the other midpoints, by use of a plotting scale, at appropriate distances along the straight line until all five midpoints have been plotted. The dis-

tance between midpoints is usually plotted to a scale of 1:25,000 since the range scale and template on the plotting fans are constructed to this scale.

- (b) To plot midpoints for an irregularly alined base (including the curved base), draw a straight line on the chart where it is desired to plot the midpoints (fig. 50). Pick a point on this line as one microphone position of the center subbase and plot the other microphone positions of the subbase at appropriate distances along the straight line (fig. 50). Plot the other microphone positions in relation to the center subbase, using a protractor to measure subbase azimuths and a scale to measure subbase lengths. The midpoints may then be plotted between the microphone positions by use of a compass or a plotting scale (fig. 50).

- (2) *Constructing normals.* The normal, or normal line (a line perpendicular to the subbase at the midpoint), may be drawn by one of three different methods; these are listed in (a) through (c) below in order of preference.

- (a) *Compass.* Using compass, preferably the bar-beam type, strike arcs of equal radii from the midpoint, cutting the subbase (or an extension of the subbase) on each side of the midpoint. From the intersection of the arcs with the subbase, strike arcs of greater radii than first used to give an intersection to the front of the

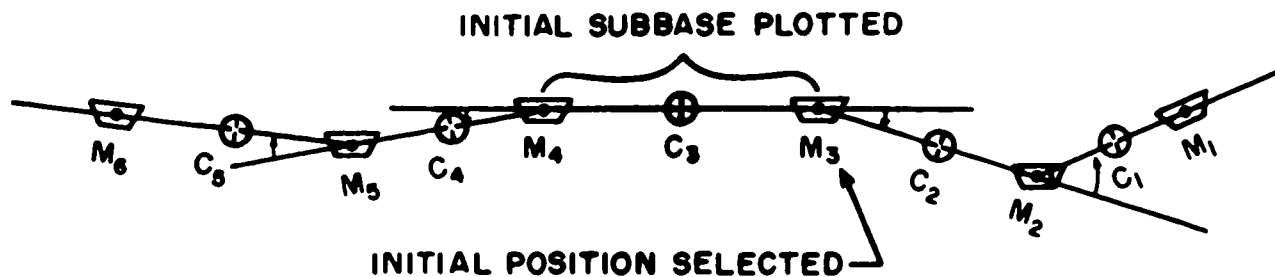


Figure 50. Plotting midpoints (irregularly alined base).

subbase. Draw a line from the intersection through the midpoint. This line is the perpendicular, or normal, of the subbase.

- (b) *Protractor*. Place the center of the protractor over the midpoint and align the straight edge of the protractor with the subbase. Draw a reference mark at the 1,600-mil (or

90°) graduation of the protractor and then draw a line through the reference mark to the midpoint. The line so constructed is the perpendicular bisector, or normal, of the subbase.

- (c) *Template*. A template for drawing the midpoints of a 4-second subbase of a straight regular base is a

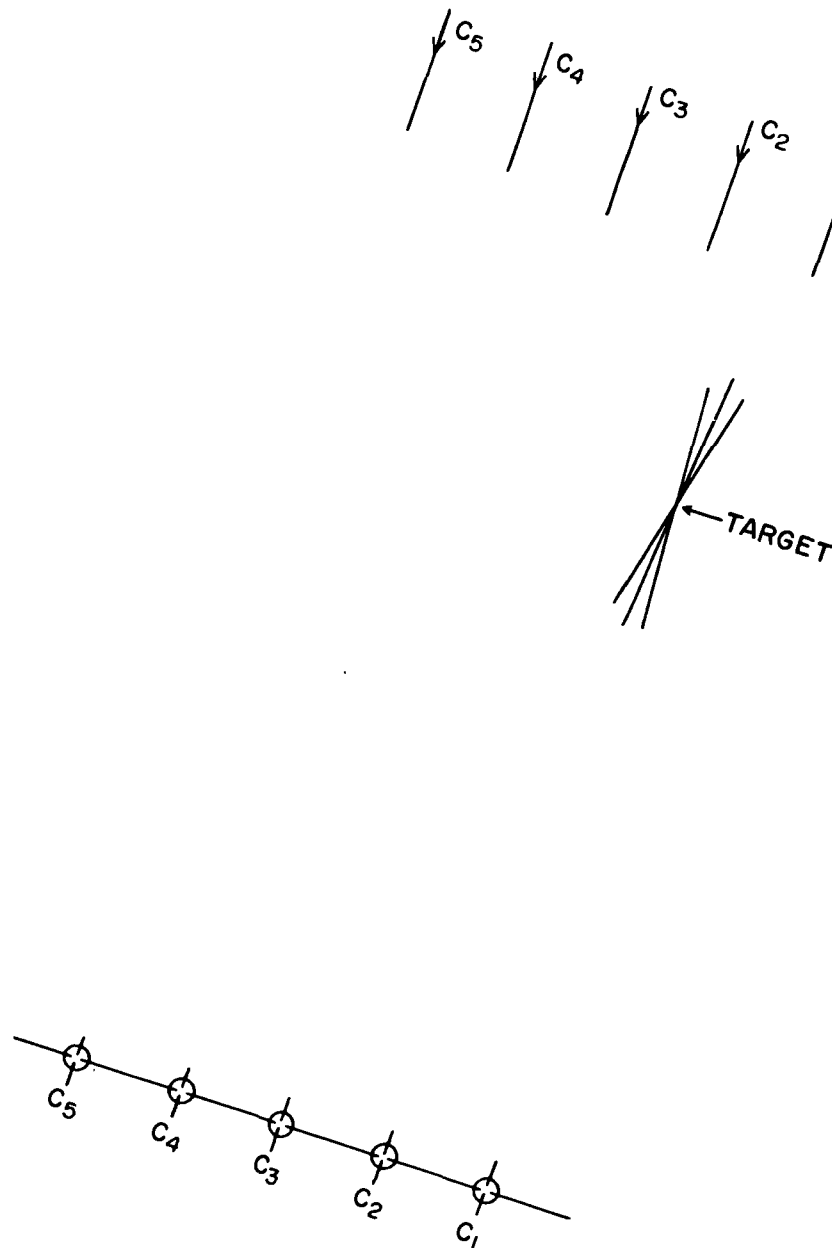


Figure 51. The 4-second subbase fan preliminary plotting chart.

component of the 4-second subbase plotting fan. A template for drawing the midpoints of a 2-second subbase of a straight regular base is a component of the all-subbase plotting fan. (Below the templates on both fans is another template for use in preparing preliminary plotting charts.) Place the lower template on the plotting fan over the midpoint plots of a base with the appropriate size subbases; the upper template marks the positions of the normals for the various subbases. With a needle, prick the position of the holes in the upper template on the plotting chart. Then draw a line from each needle prick to the midpoint plot to construct the normal. Caution must be exercised when this method is used, since enlargement of the template holes through misuse will cause errors in the location of the normals.

b. The 4-Second Subbase Fan Preliminary Plotting Chart. In plotting with the 4-second subbase fan, construct only the midpoints and normals on the plotting chart. Draw that portion of the normal which will be under the time interval scales of the plotting fan and extending 1 inch above the curved edge. Mark each normal with an inverted arrow one-half inch above the curved edge of the plotting fan, and label it with the number of its corresponding midpoint. The preliminary plotting chart for the 4-second subbase fan is then ready for plotting time intervals (fig. 51).

c. The All-Subbase Fan Preliminary Plotting Chart. In plotting with the all-subbase fan, after the normals have been constructed (*a*(2) above), scale the length of the subbase along the normal line, using the *subbase length scale* on the all-subbase fan; *only this scale can be used for this operation*. At the scaled subbase distance, draw a line perpendicular to the normal, extending it one-half inch to either side of the normal. Mark the normal with an inverted arrow one-half inch above the index point, and label the index point with the number of its corresponding midpoint. This operation is per-

formed for each subbase and its corresponding normal (fig. 52). Caution must be exercised to insure that the arrow and the number of each index point are readily identifiable since the normals for an irregular base may fall into a confusing pattern.

d. The Special All-Subbase Fan Preliminary Plotting Chart. The special all-subbase fan provides a means of graphically applying temperature and wind corrections. If this special feature of the fan is used, the final steps in the preparation of the preliminary plotting chart are somewhat different from those employed when other types of plotting fans are used. If it is not desired to employ the special feature of this fan, the fan may be used in conjunction with a 4-second subbase fan chart (*b* above) or with an all-subbase fan chart (*c* above). If the special feature of this fan is to be employed, the following additional procedures are followed after the midpoints and normal lines have been drawn and labeled.

- (1) To use the temperature scale (para. 72b(5)) to graphically apply the temperature correction, set the plotting fan vertex over the midpoint and rotate the fan until the current effective temperature reading (para. 83b) on the temperature scale is over the normal line. Draw the temperature-corrected index point, used in plotting time intervals, at the intersection of the normal line and the time line (on the center of the fan) having the value $\text{subbase length (in meters)} \times 2,$

1,000

and label the index point with the appropriate midpoint number. For example, the time line having the value 2.4 seconds is used for a 1,200-meter subbase (fig. 53). Since the intersection of the normal line and the time line is under the plastic fan, drawing the temperature-corrected index point is facilitated by measuring with a compass the distance from a point on the normal line not under the fan to the point of intersection under the fan and then sliding the fan away and marking the point of intersection with the compass.

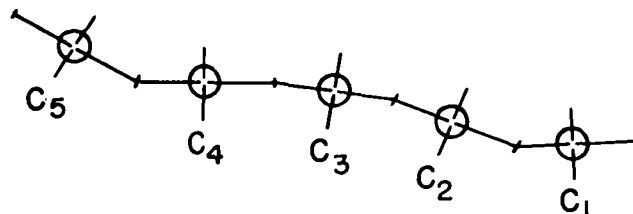
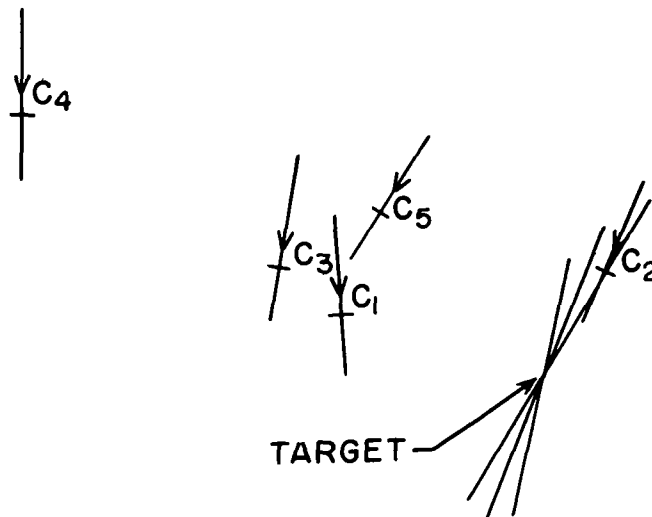


Figure 52. The all-subbase fan preliminary plotting chart.

- (2) To graphically apply the wind correction with the special all-subbase plotting fan, first determine the amount of the wind correction (para. 84), using a subbase length of 4 sound seconds and the true subbase azimuth. Then set the plotting fan vertex over the midpoint and rotate the fan until the value of the wind correction on the *outer* time interval scale is over the

normal line (with due regard for the sign of the correction). Draw a ray along the edge of the fan nearest the temperature-corrected index point and adjacent to the point (fig. 54). With the index point as the center, construct a semicircle tangent to the ray (fig. 54). When the above procedure has been completed for each subbase and its temperature-corrected index point,

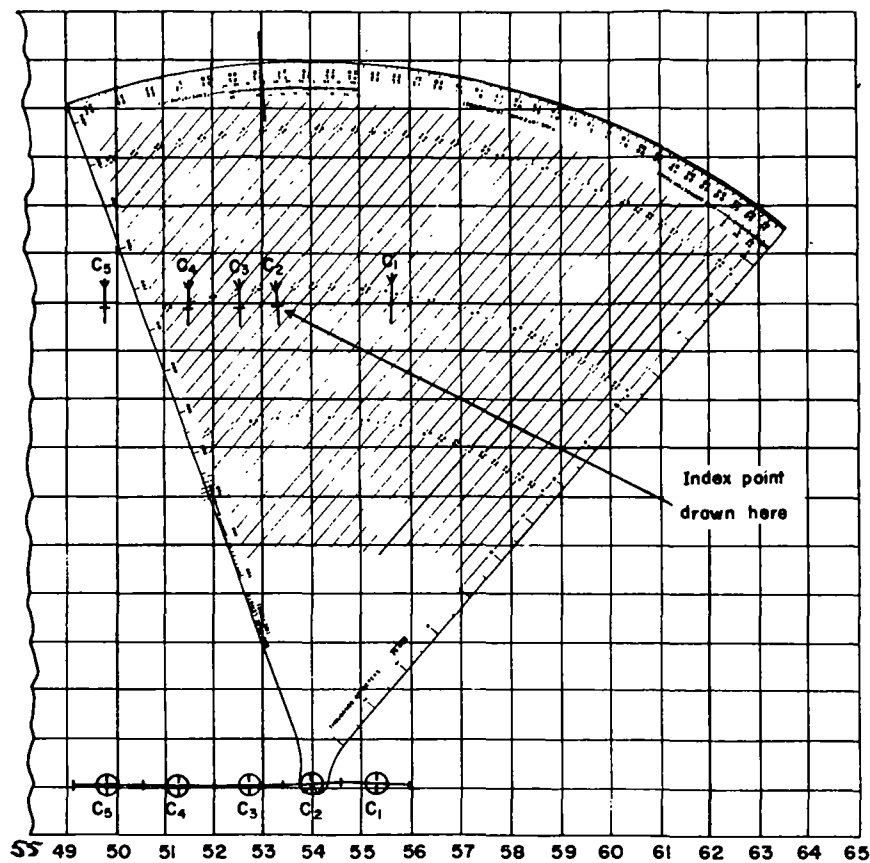


Figure 53. Constructing the temperature-corrected index point.

erase the drawn rays. The plotting chart is then ready for plotting time intervals.

- (3) To plot a time interval on the special all-subbase fan preliminary plotting chart, place the plotting fan vertex over the midpoint and rotate the fan until the time line with the value of the uncorrected time interval is tangent to the weather-corrected index curve (fig. 55). Draw a ray along the proper edge of the fan (para. 72 b). The plot of the rays thus drawn is a weather-corrected plot since the weather corrections have been applied on the chart itself.
- (4) The special all-subbase plotting fan has another special function. In many situations, it will be desirable or even necessary to use a 4-second plotting fan or a 4-second time scale with the

final plotting chart. In these instances, the time intervals (final time intervals) plotted on the final plotting chart should be either 4-second subbase time intervals or their equivalent. To determine the 4-second subbase equivalent when the time interval is plotted as in (3) above, position the fan as in (3) above and read the 4-second subbase equivalent at the position of the normal line under the *outer* (4-second) time scale. The 4-second subbase equivalent so determined will be a weather-corrected time interval, and, after application of the curvature correction (para. 86), it can be plotted on the final plotting chart by using a 4-second time interval scale.

- (5) When a wind correction exceeds in absolute value, and is opposite in sign to, the uncorrected time interval, the

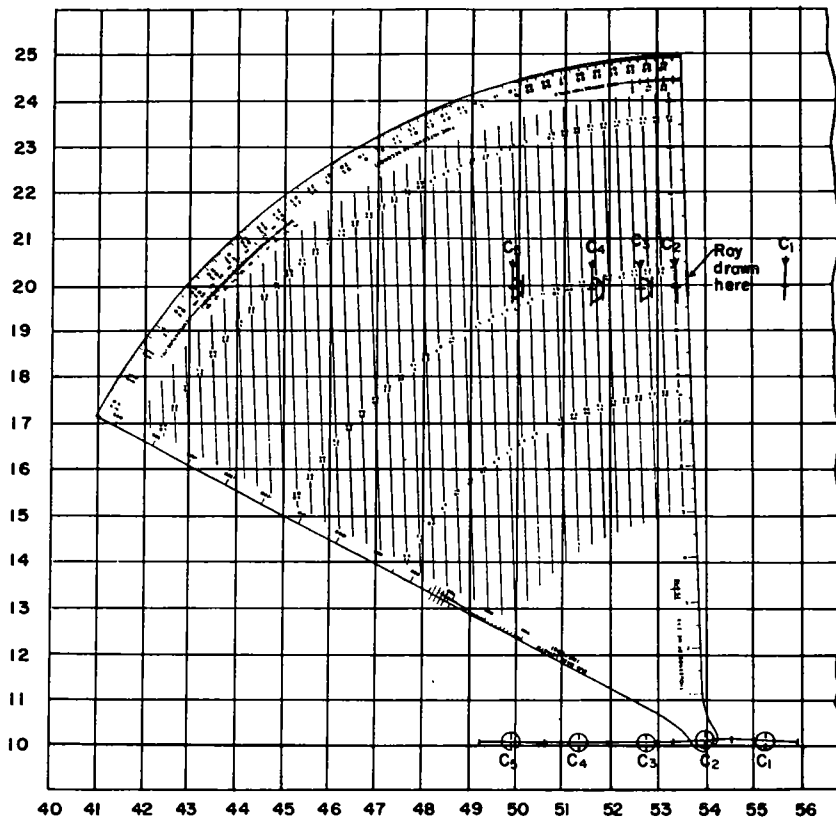


Figure 54. Constructing the weather-corrected index curve.

special all-subbase fan will not cover the normal line, and the outer time scale cannot be used to read the 4-second subbase equivalent as described in (4) above. To determine the 4-second subbase equivalent under these conditions, use the special time interval scale (para. 72b(6)). Using the outer time scale, plot a segment of an additional normal line at a 0.3-second time interval away from the established normal line on the same side of the normal as the weather-corrected index curve (fig. 56). In plotting a time interval which is less in absolute value, and opposite in sign to, the wind correction, some portion of the special correction scale will fall over the additional normal line. The value read on this scale, with a sign opposite to that of the uncorrected time interval, is the weather-corrected, 4-second subbase

equivalent of the uncorrected time interval.

76. Final Plotting Charts

a. General. Final plotting charts, always gridded, are used to plot final time intervals in order to determine the grid reference of the sound source. The preparation of a final plotting chart differs for each of the three types of plotting devices used; however, in the initial steps (plotting midpoints and constructing normals), the same procedures are used for all three devices. The most accurate plotting device available is used with the final plotting chart.

- (1) *Plotting midpoints.* Since the final plotting chart is always a gridded chart, the grid coordinates of the midpoints must be known to be able to plot them on the chart. The midpoints need not necessarily be plotted at the bottom center of the plotting chart, but they

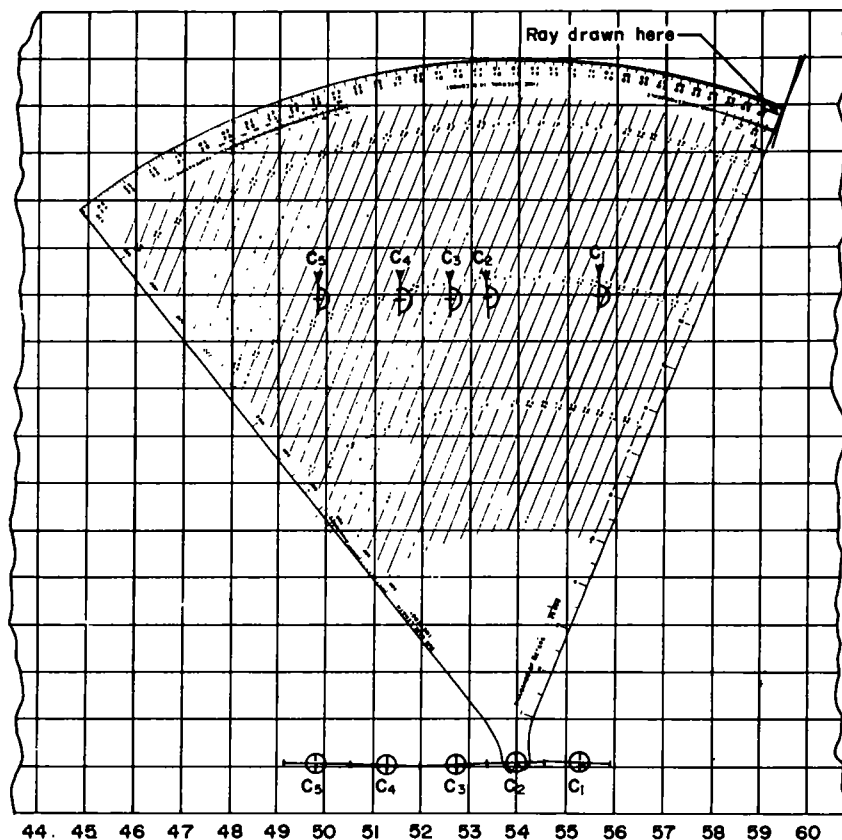


Figure 55. Plotting a time interval on the special all-subbase preliminary plotting chart.

must be so plotted that a maximum area is provided in which to plot sound source locations. Plotting the midpoints is carried out in three steps as follows:

- (a) *Numbering the grid.* Keeping the direction of ranging in mind (add 1,600 mils to the azimuth of the base), select grid squares in which to plot the midpoints that will allow the maximum plotting capability in the direction of ranging. After selecting the grid squares, number the grid lines surrounding the squares and, based on these numbered squares, number the remainder of the grid lines on the plotting chart.
- (b) *Computing midpoint coordinates.* To compute the midpoint of a subbase, average the coordinates of the subbase microphone positions. Per-

form the operation for each subbase. For example—

Coordinates of $M_1 = (324683.5-47176.7)$

Coordinates of $M_2 = (325845.8-47269.1)$

Coordinates of $C_1 = (650528.8-94445.8 \div 2) = (325264.4-47222.9)$

- (c) *Plotting midpoint coordinates.* Using a boxwood plotting scale and the techniques outlined in FM 6-40, plot the midpoint coordinates on the previously gridded plotting chart ((a) above).
- (2) *Constructing normals.* The normal lines for the subbases on the final plotting chart are constructed by a combination of computation and plotting. The first step, computation, consists of

<u>STEPS</u>		<u>E</u>	<u>N</u>
	M_1 M_2	24683.5 25845.3	47176.7 47269.1
DETERMINE dE AND dN		dE = $\frac{1161.8}{}$	dN = $\frac{92.4}{}$
REVERSE dE AND dN		dE = $\frac{92.4}{}$	dN = $\frac{1161.8}{}$
MULTIPLY BY 10		$\frac{ \times 10}{}$	$\frac{ \times 10}{}$
NEW dE AND dN		dE = $\frac{924.0}{}$	dN = $\frac{11,618.0}{}$
COMPUTE AZIMUTH OF NORMAL	AZIMUTH $M_1 - M_2 = 1519.16$ MILS AZIMUTH $C_1 - N_1 = 3119.16$ MILS (AZIMUTH $M_1 - M_2 + 1600$ MILS)		
DETERMINE SIGNS OF dE AND dN	AZIMUTH $C_1 - N_1$ IN II QUADRANT SIGNS: dE IS + dN IS -		
APPLY dE AND dN TO MIDPOINT COORDINATES	C_1	dE = $\frac{25264.4}{+924.0}$	dN = $\frac{47222.9}{-11618.0}$
<u>NORMAL POINT</u>	N_1	26188.4	35604.9

Figure 57. Computation of normal points.

tion of the preliminary plotting chart as given in paragraph 75c.

d. *The Special All-Subbase Fan Final Plotting Chart.* The special all-subbase fan is not normally used with a final plotting chart; however, if the fan is used, the final steps in the construction of the final plotting chart are the same as those in the construction of the preliminary plotting chart for the 4-second and all-subbase fans as described in paragraph 75b and c. Since corrections will always be applied before the final plot is made, the special feature of the fan will not be used.

77. Approximate Grid Plotting Chart

In some situations, particularly in fast-moving operations, the sound ranging base and the firing units may not be able to establish a common grid system. In such situations, it is highly desirable that the sound platoon determine and establish the grid system of the firing unit on the sound plotting chart to facilitate the ex-

change of information and data. If both units use a common origin for direction, such as grid north, the firing unit's grid system may be approximated on the sound plotting chart by a procedure called "swinging the grid," a method accomplished by sound ranging on a shellburst from the friendly unit. The approximate grid so established, though not precisely accurate, will facilitate the exchange of information and data. As weather conditions change, the location of the approximate grid will also change; therefore, the approximate grid must be re-established at regular intervals. The procedure in establishing this approximate grid is as follows:

a. The sound platoon requests that the firing unit fire a marking round at its primary registration point and report the firing chart grid reference of this registration point. The sound platoon then ranges on a series of rounds fired at the registration point by the firing unit, and the mean location with all corrections applied,

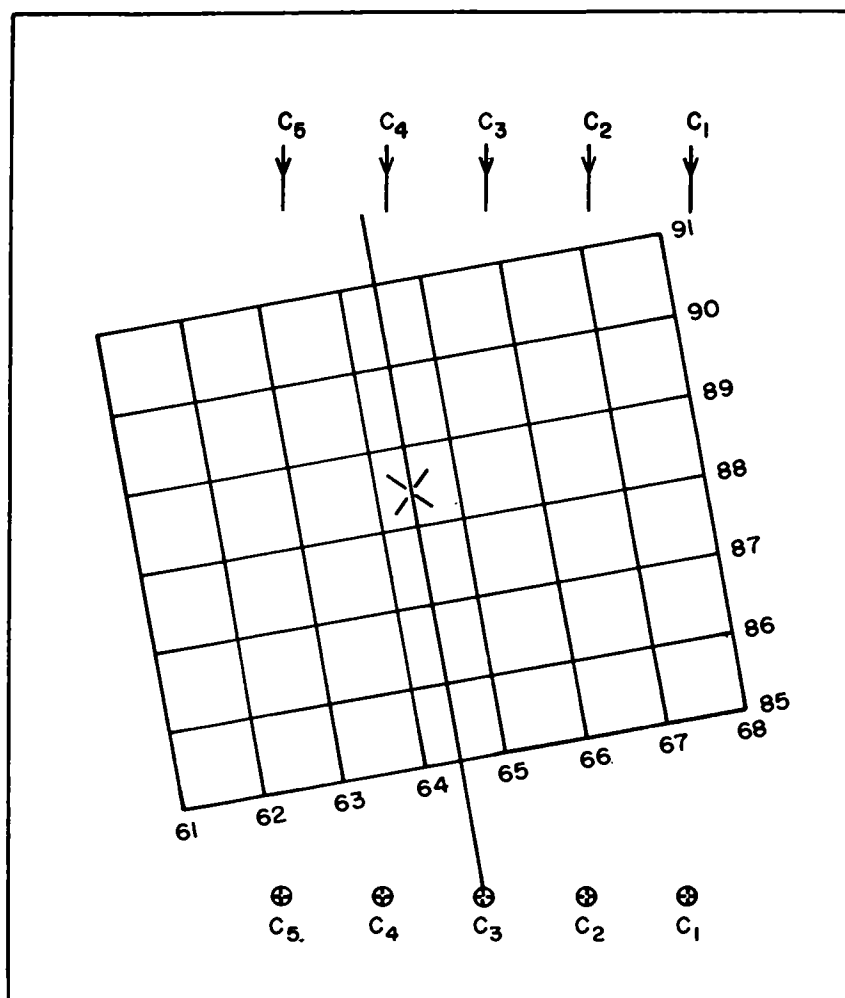


Figure 58. Approximate grid plotting chart.

for two or more rounds is plotted on an ungridded plotting chart.

b. The grid reference of the registration point, as reported by the firing unit, is plotted on the center grid square of a transparent grid sheet by using a boxwood plotting scale. The remaining grid lines of the transparent grid sheet are then numbered in relation to the plotted location of the registration point.

c. A ray is drawn on the ungridded plotting chart from C_3 to the location of the registration point as determined by sound ranging, and the angle from the normal line for C_3 to the constructed ray is measured. The azimuth of the ray can then be determined by adding (subtracting) the measured angle to (from) the azimuth of the normal line.

d. A line is drawn on the transparent grid sheet at the back-azimuth of the ray from C_3 to the registration point. This line originates at the plotted location of the registration point and extends to the outer edge of the transparent grid sheet.

e. The transparent grid sheet is then positioned over the ungridded plotting chart so that the location of the registration point and the line to it from C_3 coincide. The transparent grid sheet is then fixed to the plotting chart, and the approximate grid reference of the firing unit can be read directly from the plotting chart (fig. 58).

f. If the sound ranging base and the firing unit have not used a common origin for direction, common direction can be established by

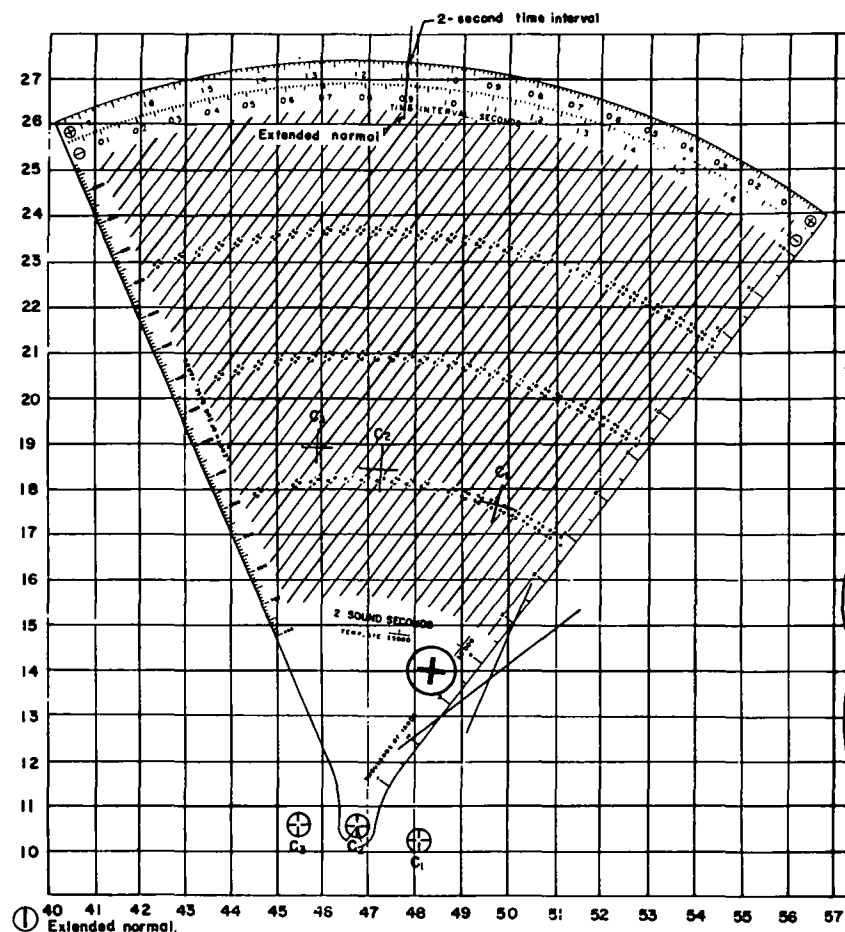


Figure 59. Adjustment of normals with the all-subbase fan.

the sound platoon by any of the following methods:

- (1) Ranging on both the shellburst and the weapon firing and then plotting the line of direction between them.
- (2) Ranging on several rounds fired at the same azimuth but at different ranges and then plotting the line of direction between them.
- (3) Measuring the azimuth of the sound ranging base and the line of fire with a common instrument such as the aiming circle of the firing unit.

78. Adjusting Normals

When relative locations (para. 114a) are plotted, the normals can be adjusted to reduce the size of the polygon of error and to facilitate the evaluation of the polygons by inspection.

The adjustment does not correct for weather effects or for errors in survey; it simply reduces the size of the polygon of error. The operations required to adjust the normals when using the 4-second subbase fan differ from those required when using the all-subbase plotting fan.

a. *The 4-Second Subbase Fan Adjustment of Normals.* In the adjustment of normals when the 4-second subbase fan is used, only four microphones, generally, are used in making relative locations. Only one normal needs to be adjusted in order to produce a point plot. Normal number 2 is adjusted to obtain a point plot at the intersection of rays 1 and 3 since this intersection is always closer to the center of the polygon than the other two intersections. To adjust normal number 2, position the plotting fan so that the vertex is over midpoint 2 and one edge of the fan passes through the

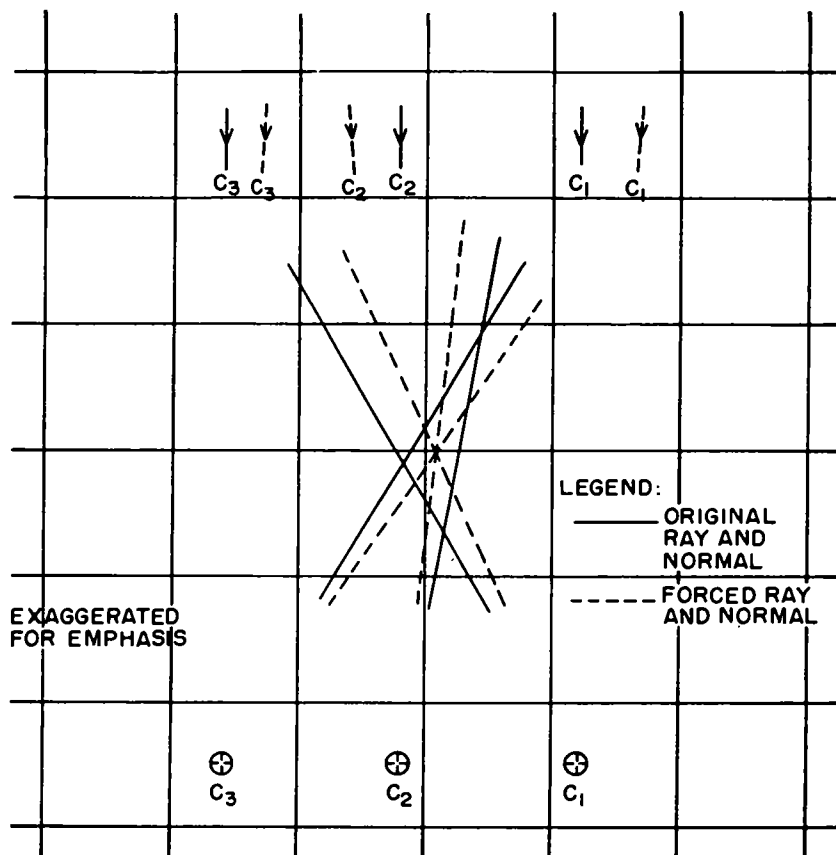


Figure 60. Forcing plots.

a. Straight Regular Base. Assume that on a five-microphone straight base record initial breaks were recorded on all traces except the one for M_2 . The sound source could not be located by normal methods since rays could be determined for only the subbases M_3 – M_4 and M_4 – M_5 . In this situation, the missing trace plot procedure is employed and a ray is constructed for the double-length subbase M_1 – M_3 . The procedure for plotting the ray for the double-length subbase is as follows:

- (1) Determine the time interval for the double-length subbase (M_1 – M_3) and divide it by 2. *All further reference to the time interval refers to this half value.* Determine and apply the weather corrections to this time interval in the usual manner.
- (2) Using M_2 as a midpoint, construct a normal line and, using this normal, plot the weather-corrected time interval determined in (1) above on the

preliminary plotting chart. Plot all other weather-corrected time intervals in the usual manner.

- (3) Apply the curvature corrections to the weather-corrected time interval determined in (1) above in the usual way, but use only *half* the actual distance from the midpoint to the sound source in entering the curvature correction chart.
- (4) Plot the corrected time interval on the final plotting chart.

b. Curved and Irregular Bases. The procedure followed for either a curved base or an irregular base differs from that followed for a straight regular base in that the half-value time interval (*a*(1) above) must be plotted from a midpoint halfway between the microphones of the double-length subbase but which is not located at a microphone position. If a break was not recorded on the trace for M_3 , the missing trace plot procedure is as follows:

- (1) Average the coordinates of M_2 and M_4 . The resulting location is that of the required midpoint.
- (2) Construct a normal line for the computed midpoint.
- (3) Compute the azimuth and distance between M_2 and M_4 ; this is the new subbase direction and length. Divide the

subbase length by 2 and construct a plotting index point (para. 75c).

- (4) Determine the time interval for subbase M_2-M_4 and divide it by 2. Plot the time interval and apply corrections as described in *a* above, but use the azimuth and half the subbase length computed in (3) above to enter the wind and curvature correction charts.

CHAPTER 12

DETERMINATION AND CORRECTION OF TIME INTERVALS

81. Determination of Time Intervals

a. General. To plot the location of a sound source from which a sound wave has been detected and recorded by the sound ranging set, the time intervals between the arrival of the sound wave at adjacent pairs of microphones must be determined. These time intervals, called *initial time intervals*, are determined by computations made on DA Form 6-4, Sound Plotting Record.

b. Initial Time Intervals. To determine initial time intervals, read the arrival time of the sound wave at each microphone (mic) (para. 65c), and enter the time on DA Form 6-4 (fig. 61) in the appropriately numbered space in the *time readings* section of the form. To compute the proper time intervals, enter the arrival time at each microphone above or below the arrival time at the next *higher* numbered microphone in the *results to* (—) and *results to* (+) spaces. If the arrival time at the lower numbered microphone is larger than that at the higher numbered microphone, enter the arrival time in the *results to* (—) space; if it is smaller, enter the arrival time in the *results to* (+) space. This places the arrival times at the adjacent microphones in the proper position to perform a simple subtraction to obtain the time interval. Enter the result of the subtraction, the time interval, in the appropriately numbered column of the *time interval* space. These columns are numbered from 1 to 5 in consonance with the numbering of the midpoints; therefore, plot the time interval between microphones 1 and 2 from midpoint 1, etc. Enter the time interval in the + or — section of this column as indicated by the entry of the arrival time at the lower numbered microphone in the *results to* (—) or *results to* (+) spaces. It will be noted that when the lower numbered microphone detects the sound wave first (sound source to the right of the normal), a plus time interval re-

sults; when the higher numbered microphone detects the sound wave first (sound source to the left of the normal), a minus time interval results.

In figure 61, the following time intervals were computed:

M_1-M_2 : —1.070
 M_2-M_3 : —0.551
 M_3-M_4 : +0.011
 M_4-M_5 : +0.571
 M_5-M_6 : +1.102

82. Weather Corrections

a. General. Since the speed and direction of a sound wave traveling through the air are affected by weather conditions (para. 20), the existing weather conditions must be determined and corrections must be applied to the initial time intervals to compensate for variations from standard weather conditions. The corrections applied, consisting of temperature and wind corrections, are known collectively as *weather corrections*. The initial time intervals, when corrected for weather conditions, are converted to time intervals which would have been recorded had standard weather conditions (para. 20) existed at the time of the recording.

b. Weather Data. The existing effective values of wind and temperature are computed on DA Form 6-4 by using the procedures described in FM 6-15. The meteorological message so computed may be provided by either sound platoon personnel in the vicinity of the sound ranging command post using equipment organic to the sound platoon, or it may be provided by the meteorological section of the field artillery target acquisition battalion or any other meteorological station in the vicinity. Any message used should be determined from a position as close as possible to the center of the sound ranging base so that weather conditions existing at the sound ranging base will be re-

RECORD NUMBER		SOUND PLOTTING RECORD						DATE	
METRO MSG TIME		TEMPERATURE	CONVERSION NUMBER	SUBBASE	AZIMUTH	LENGTH	CALC FACTOR	BASE LOCATION	
21								19	
1400	80	OF	1-2	50	M			BALD RIDGE	
WIND DIRECTION	WIND SPEED	WIND CORRECTION	2-3		M			BASE TYPE	
700	20	MPH	3-4		M			6 MIC 4-SEC STRAIGHT	
			4-5		M				
			5-6		M				
TIME READINGS									
RESULTS TO (-)		3.072	2.002						
1 3.072	2 2.002	3 1.451	4 1.462	5 2.033	6 3.135				
RESULTS TO (+)					1.451		1.462		2.033
		C 1	C 2		C 3		C 4		C 5
		-	+	-	+	-	+	-	+
TIME INTERVAL		1.070	0.551		0.011		0.571		1.102
TEMP CORR. OR									
ESTIMATED TIME									

Figure 61. Computation of initial time intervals on DA Form 6-4.

flected. The data obtained from the meteorological message are entered on DA Form 6-4 in the temperature, wind direction, and wind speed spaces.

83. Temperature Correction

a. *General.* The temperature correction is determined by use of the temperature correction chart (fig. 62). Since this chart is entered only with the values of the initial time intervals (para. 81b) and the effective temperature (FM 6-15) (length or type of subbase is not considered), the one chart can be used with any type or size of sound ranging base.

b. *Temperature Correction Chart.* As illustrated in figure 62, the temperature correction chart consists of two parallel vertical scales, one near each edge of the chart, and a diagonal scale.

- (1) The left vertical scale is labeled "TIME INTERVAL, SECONDS." It is graduated in 0.01-second increments from 0 to 3.000 seconds and is numbered at 0.1-second intervals.
- (2) The right vertical scale is labeled "CORRECTION, SECONDS." It is graduated in 0.001-second increments from 0 to 0.150 seconds and is numbered at 0.005-second intervals.
- (3) The diagonal scale is labeled "TEMPERATURE, °F." This scale extends from the zero point of the CORRECTION, SECONDS scale upward to-

ward the zero point of the TIME INTERVAL, SECONDS scale. The right side of the diagonal scale is graduated in 1° increments from +50° F. to +140° F; the left side of the diagonal scale is graduated in 1° increments from +50° F. to -40° F.

c. *Determination of Temperature Correction.*

- (1) To determine a temperature correction, place a straightedge (preferably a hairline on a transparent plastic strip) through the initial time interval value on the TIME INTERVAL, SECONDS scale and the effective temperature value on the TEMPERATURE °F. scale in such a manner that the right end of the straightedge is over the CORRECTION, SECONDS scale (fig. 62). The point at which the straightedge intersects the correction scale is the numerical value of the correction. This value is read and applied to the nearest 0.001 second (fig. 62).
- (2) If the effective temperature is above 50° F. the correction has the same sign as that of the time interval; if the effective temperature is below 50° F. the correction has the opposite sign from that of the time interval.
- (3) To determine the temperature correction for a time interval larger than that shown on the TIME INTERVAL, SECONDS scale of the chart, deter-

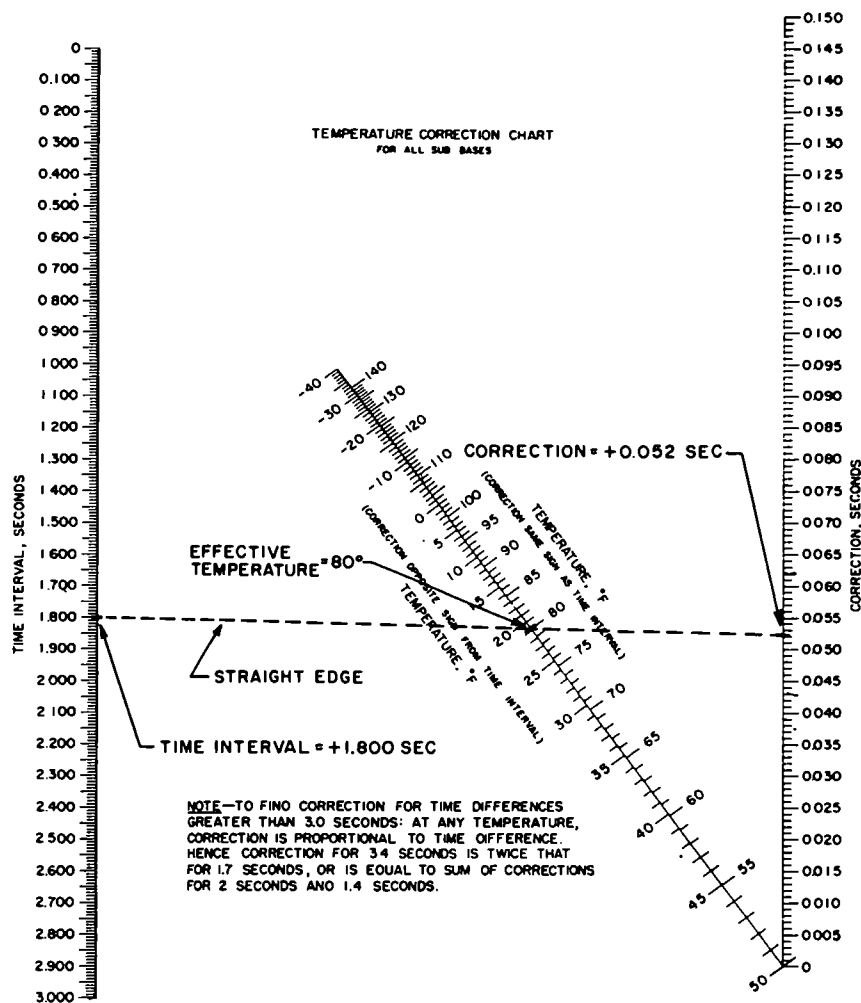


Figure 62. Determining a temperature correction on the temperature correction chart.

mine the correction for half the time interval and multiply this value by 2. For example, the correction for 3.4 seconds is twice that for 1.7 seconds.

- (4) In figure 63, the time interval is +1.8 seconds and the effective temperature is 80° F. The correction read from the chart is +0.052 second.

84. Wind Correction

a. General. The wind correction is determined by use of the wind corrector M1 or the wind correction chart. Both the wind corrector and the wind correction chart are entered with the values of the wind speed, wind direction, subbase length, and direction (azimuth) of the subbase; therefore, wind corrections are the same for all subbases of straight regular sound

ranging bases, whereas wind corrections vary for each subbase of curved bases or irregular bases. The correction determined for each subbase is used for all sound source locations until new weather data are determined. The values necessary for entering the correction devices are obtained from DA Form 6-4.

b. Wind Corrector M1. The wind corrector M1, as illustrated in figure 63, is used to determine corrections for 4.0-, 4.5-, 5.0-, and 5.5-second subbases only.

- (1) A metal strip with four wind speed scales engraved thereon is mounted on the wind arm. The wind speed scales, graduated for 4.0-, 4.5-, 5.0-, and 5.5-second subbases in miles per hour (MPH), from 3 up to 30 miles per hour, are along each edge, front and

back, of the metal strip. To determine a wind correction, attach the strip to the wind arm so that the desired scale is along the edge passing through the pivot point. Then set the wind arm at the reported wind azimuth in degrees on the outer azimuth scale or in mils on the inner azimuth scale. Position the five subbase azimuth markers, which slide between the inner and

outer azimuth scales, on the azimuth scales at the *azimuth* of each subbase (only one subbase is used for the straight regular base). Rotate the central disk until the arrow thereon lines up with the first subbase marker and read the wind correction to the nearest 0.001 second from the parallel correction lines on the central disk opposite the wind speed on the wind

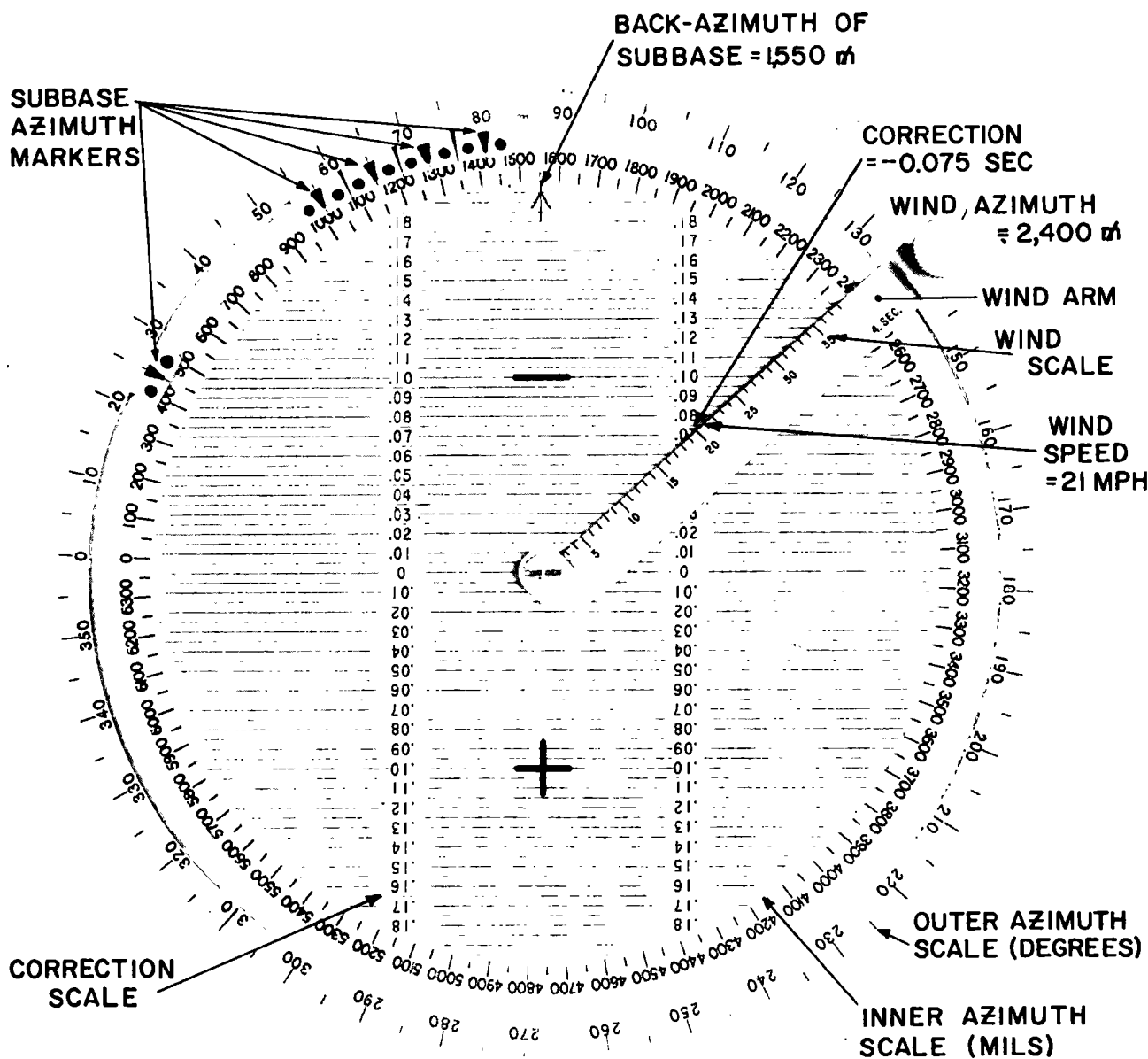


Figure 63. The wind corrector M1.

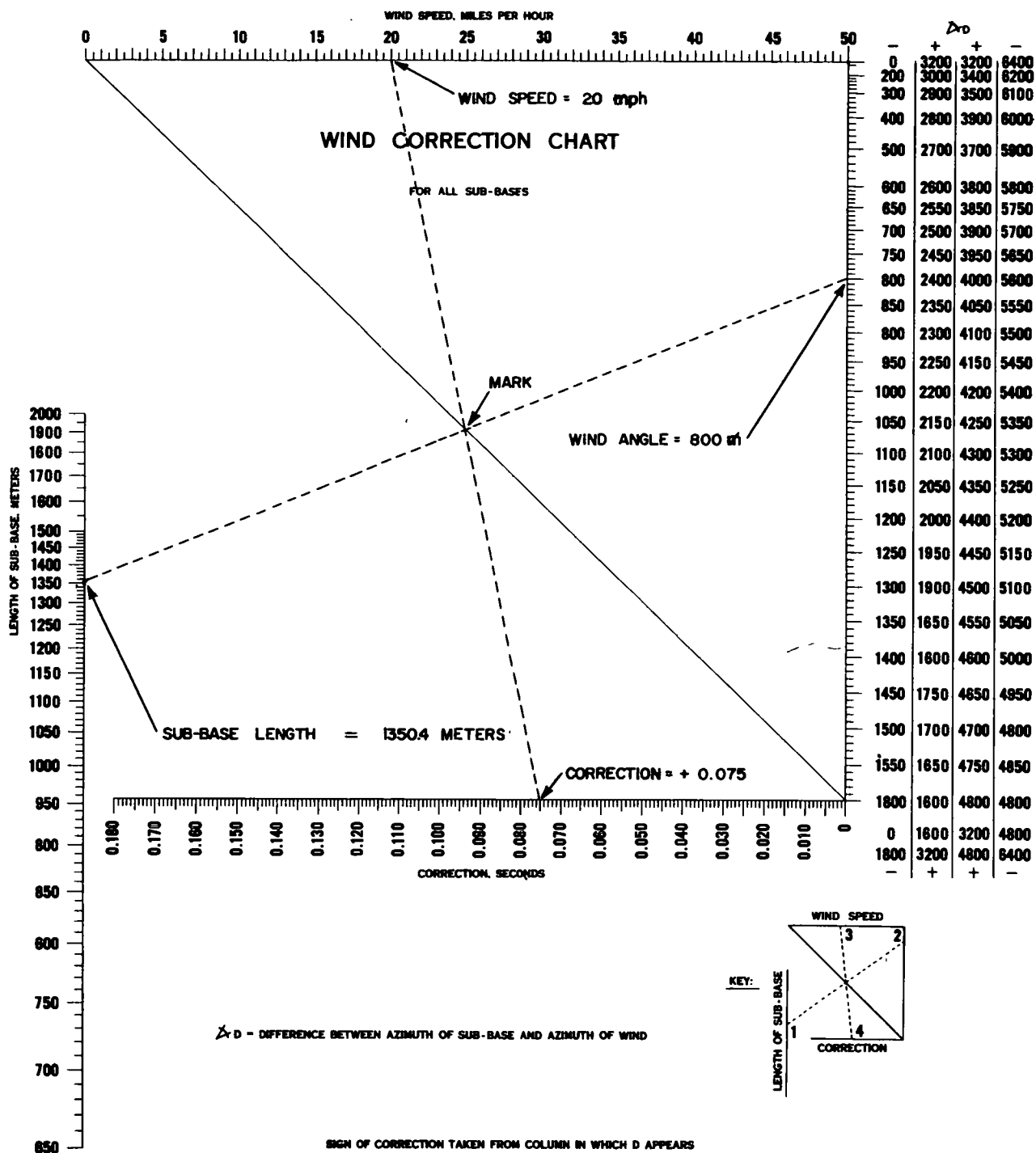


Figure 64. The wind correction chart.

arm. The sign of the correction is indicated on the disk. Repeat this operation for each subbase (except in the case of straight regular bases) and

apply the determined wind correction to each initial time interval.

- (2) In figure 63, the wind azimuth is 2,400 mils, the effective wind speed is 21

miles per hour, and the *azimuth* of the 4-second subbase is 1,550 mils. The wind correction read from the parallel correction lines opposite the wind speed scale is -0.075 second.

- (3) To determine the wind correction when the wind speeds exceed 30 miles per hour, determine the correction for half the wind speed and multiply this value by 2. For example, the correction for a 40-mile-per-hour is twice that of a 20-mile-per-hour wind.

c. Wind Correction Chart. The wind correction chart, shown in figure 64, can be used to determine corrections for subbases of any length. The wind correction chart is composed of four scales. Along the left side is a LENGTH OF SUBBASE, SECONDS scale, graduated in meters. Along the top is a WIND SPEED, MILES PER HOUR scale, calibrated in miles per hour and marked at 0.5-mile-per-hour intervals. On the right side is an $< D$ (wind angle, mils) scale consisting of a graduated scale and four columns of figures. The wind angle ($< D$) is the difference in the azimuth of the base (subbase) and the azimuth of the wind. At the bottom of each of the four columns is a plus or minus sign. These signs indicate the sign of the correction for all wind angles found within that column. Along the bottom is a CORRECTION, SECONDS scale, graduated in 0.001-second intervals from 0 to 0.180 second. A diagonal line extends through the center of the chart, from the 0 point on the CORRECTION, SECONDS scale to the 0 point on the WIND SPEED, MILES PER HOUR scale. Brief instructions on the use of the chart are found below the CORRECTION, SECONDS scale.

d. Determination of Wind Correction.

- (1) To determine a wind correction using this chart, place a straightedge through the proper subbase length on the LENGTH OF SUBBASE scale (fig. 65) and the effective wind angle on the $< D$ scale (fig. 65). Then make a short mark on the diagonal line where it is intersected by the straightedge. Place the straightedge through the effective wind speed on the WIND

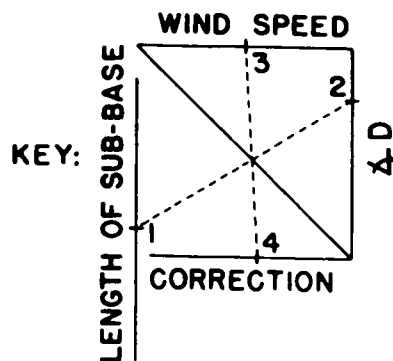


Figure 65. Key to the use of the wind correction chart.

SPEED scale (fig. 65) and the point of intersection of the short mark and the diagonal line (fig. 65) so that the straightedge is over the CORRECTION scale. Read the wind correction at the point where the straightedge crosses this scale (fig. 65). The sign of the correction is the same as that of the wind angle column entered.

- (2) In the example in figure 64, the wind angle is 800 mils (1,500-mil subbase *azimuth* minus 700-mil wind *azimuth*), the effective wind speed is 20 miles per hour, and the subbase length is 4 sound seconds (1350.4 meters). The correction read on the correction scale is -0.075 second.

Note. If the wind angle had been 2,400 mils, the correction would have been $+0.075$ second.

- (3) To determine the wind correction when a straightedge placed through the effective wind speed on the WIND SPEED, MILES PER HOUR scale and the point of intersection of the short mark and the diagonal line will not be over the CORRECTION, SECONDS scale, determine the correction for half the wind speed and multiply by 2. For example, the correction for a 40-mile-per-hour wind is twice that for a 20-mile-per-hour wind.

85. Weather-Corrected Time Intervals

The computed temperature correction (para. 83) and wind correction (para. 84) are entered

RECORD NUMBER <i>21</i>		SOUND PLOTTING RECORD (FM 6-122)						DATE <i> </i> 19 <i> </i>	
METRO MSG TIME <i>1400</i>	TEMPERATURE <i>80</i> OF	CONVERSION NUMBER	SUBBASE	AZIMUTH	LENGTH	CALC FACTOR	BASE LOCATION <i>BALD RIDGE</i>		
WIND DIRECTION <i>700</i>	WIND SPEED <i>20</i> MPH	WIND CORRECTION	1-2	<i>4500</i>	M	M	BASE TYPE <i>6-MIC 4-SEC STRAIGHT</i>		
			2-3		M	M			
			3-4		M	M			
			4-5		M	M			
			5-6		M	M			
TIME READINGS									
RESULTS TO (-)		<i>3.072</i>	<i>2.002</i>						
1 <i>3.072</i>	2 <i>2.002</i>	3 <i>1.451</i>	4 <i>1.462</i>	5 <i>2.033</i>	6 <i>3.135</i>				
RESULTS TO (+)				<i>1.451</i>	<i>1.462</i>	<i>2.033</i>			
C 1 C 2 C 3 C 4 C 5									
	-	+	-	+	-	+	-	+	-
TIME INTERVAL	<i>1.070</i>		<i>0.551</i>			<i>0.011</i>		<i>0.571</i>	<i>1.102</i>
TEMP CORR. OR TEMP-CONVERTED TIME	<i>0.031</i>		<i>0.016</i>			<i>0.001</i>		<i>0.015</i>	<i>0.035</i>
WIND CORRECTION		<i>0.075</i>		<i>0.075</i>		<i>0.075</i>		<i>0.075</i>	<i>0.075</i>
SUB TOTALS	<i>1.101</i>	<i>0.075</i>	<i>0.567</i>	<i>0.075</i>		<i>0.087</i>		<i>0.661</i>	<i>1.209</i>
SUBTRACT	<i>0.075</i>		<i>0.075</i>						
WEATHER CORRECTED TIME INTERVAL	<i>1.026</i>		<i>0.492</i>			<i>0.087</i>		<i>0.661</i>	<i>1.209</i>
CURVATURE CORRECTION									

Figure 66. Partially completed DA Form 6-4 showing entries for weather-corrected time intervals.

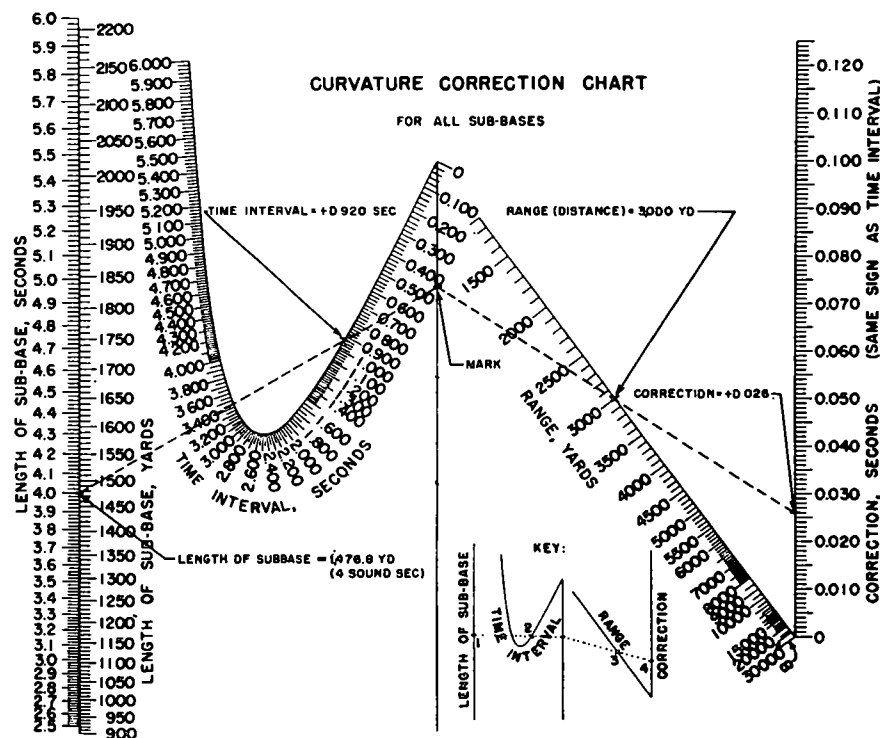


Figure 67. Curvature correction chart.

on DA Form 6-4 in the + or — column (depending on the sign of the correction) of the appropriate midpoint column. The subtotals of the + and — columns are then determined and the results are algebraically added to determine the *weather-corrected time intervals*. An example of these operations is given in figure 66.

86. Curvature Correction

a. *General.* The size of angle $\odot$ must be determined to plot the location of the sound source. Since the method of determining the size of angle $\odot$ contains certain inaccuracies (para. 19), a *curvature correction* must be applied to the weather-corrected time intervals to obtain an accurate location. The curvature correction has no relation to the curvature of the earth but relates only to the accuracy of the determination of angle $\odot$. To determine the curvature correction, make a preliminary plot, using the weather-corrected time intervals. Analyze the plot, and measure the approximate distances from the subbase midpoints to the center of the weather-corrected plot. Determine the curvature correction for all subbases by use of the curvature correction chart (fig. 67).

b. *Curvature Correction Chart.* The curvature correction chart is composed of four scales. Along the left side is a LENGTH OF SUB-

BASE scale, graduated on the left side in *seconds* (sound seconds) and on the right side in *yards*. The *seconds* scale is graduated at 0.02-second intervals, and the *yard* scale is graduated at 10-yard intervals. In the left center of the chart, to the right of the LENGTH OF SUBBASE scale, is a parabolic TIME INTERVAL, SECONDS scale. A vertical line starts at the 0 point on this scale and extends downward, parallel to the LENGTH OF SUBBASE scale, to the lower portion of the chart. Along the right side of the chart is a CORRECTION, SECONDS scale graduated from 0 to 0.125 seconds at 0.001-second intervals. Starting at the 0 point on this scale and extending upward diagonally to the left is a RANGE, YARDS scale. A key to the use of the correction chart is found immediately below the RANGE, YARDS scale (fig. 68).

c. *Determination of Curvature Correction.*

- (1) To determine a curvature correction, place a straightedge through the proper subbase length on the LENGTH OF SUBBASE scale (1, fig. 63) and the weather-corrected time interval value on the TIME INTERVAL scale (2, fig. 68). Then, on the vertical line extending down from the 0 point on the TIME INTERVAL

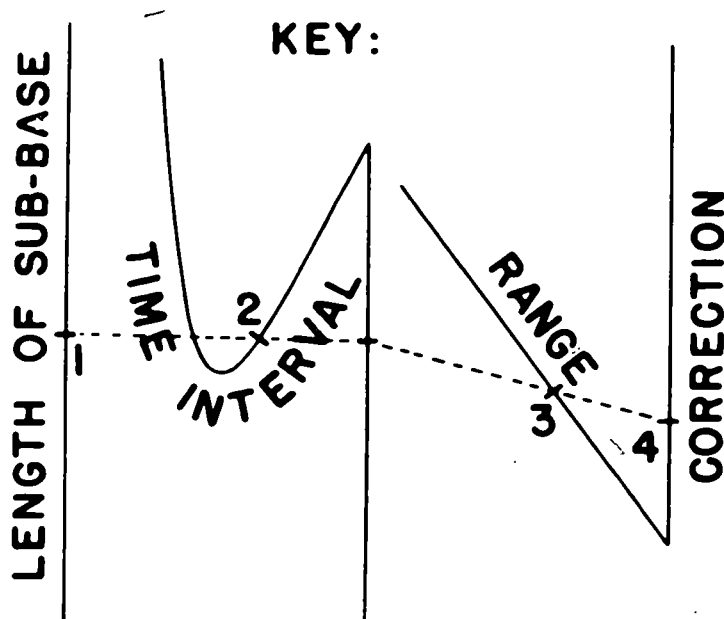


Figure 68. Key to the use of the curvature correction chart.

scale, make a short mark where the straightedge intersects this line (fig. 68). Place the straightedge through the point of intersection of the drawn mark and the vertical line and the desired distance on the RANGE scale (3, fig. 68) so that the straightedge is over the CORRECTION scale (4, fig. 68). Read the curvature correction at the point where the straightedge crosses this scale. The sign of the correction is *always* the same as that of the weather-corrected time interval since it must always *increase* the size of that time interval.

- (2) In the example in figure 67, the sub-base length is 1476.8 yards (4 sound seconds), the weather-corrected time interval is +0.920 second, and the

range (distance) is 3,000 yards. The correction read from the correction scale is +0.026 second.

87. Final Time Intervals

Enter the approximate distance from each midpoint to the center of the weather-corrected plot on DA Form 6-4, (fig. 69) in the appropriate *approximate distance* space. When the curvature correction has been determined for each midpoint, enter it in the proper (+ or -) column of the *curvature correction* space. The curvature corrections, with the same sign as the weather-corrected time intervals and the result, the *final time intervals*, is entered on DA Form 6-4 in the *final time interval* space. The final time intervals are used to make the location or final plot of the sound source.

RECORD NUMBER <u>21</u>		SOUND PLOTTING RECORD (FM 6-122)						DATE _____ 19__	
METRO MSG TIME <u>1400</u>	TEMPERATURE <u>80</u> °F	CONVERSION NUMBER	SUBBASE 1-2 <u>X</u>	AZIMUTH <u>45</u>	LENGTH <u>4</u> M	CALC. FACTOR	BASE LOCATION <u>BALD RIDGE</u>		
WIND DIRECTION <u>700</u> M	WIND SPEED <u>20</u> MPH	WIND CORRECTION	3-4 <u>0</u>	4-5 <u>0</u>	5-6 <u>0</u>		BASE TYPE <u>6 MK 4-SEC STRAIGHT</u>		
TIME READINGS									
RESULTS TO (-)	<u>3.072</u>	<u>2.002</u>							
1 <u>3.072</u>	2 <u>2.002</u>	3 <u>1.451</u>	4 <u>1.462</u>	5 <u>2.003</u>	6 <u>3.135</u>				
RESULTS TO (+)			<u>1.451</u>	<u>1.462</u>	<u>2.003</u>				
	C 1		C 2		C 3		C 4		C 5
	-	+	-	+	-	+	-	+	-
TIME INTERVAL	<u>1.070</u>		<u>0.551</u>			<u>0.011</u>		<u>0.571</u>	<u>1.102</u>
TEMP. CORR. OR TEMP. CONVERTED TIME	<u>0.031</u>		<u>0.016</u>			<u>0.001</u>		<u>0.015</u>	<u>0.032</u>
WIND CORRECTION		<u>0.075</u>		<u>0.075</u>		<u>0.075</u>		<u>0.075</u>	<u>0.075</u>
SUB TOTALS	<u>1.101</u>	<u>0.075</u>	<u>0.567</u>	<u>0.075</u>		<u>0.087</u>		<u>0.661</u>	<u>1.209</u>
SUBTRACT	<u>0.075</u>		<u>0.075</u>						
WEATHER CORRECTED TIME INTERVAL	<u>1.026</u>		<u>0.492</u>			<u>0.087</u>		<u>0.661</u>	<u>1.209</u>
CURVATURE CORRECTION	<u>0.017</u>		<u>0.011</u>			<u>0.002</u>		<u>0.014</u>	<u>0.019</u>
FINAL TIME INTERVAL	<u>1.043</u>		<u>0.503</u>			<u>0.089</u>		<u>0.675</u>	<u>1.228</u>
APPROXIMATE DISTANCE	<u>3,800</u>	<u>3,400</u>	<u>3,000</u>	<u>3,500</u>	<u>3,900</u>				
FROM (FILE NR) / TIME REPORTED <u>8</u> / <u>1445</u>	GRID REFERENCE <u>57698436</u>				ACCURACY <u>100</u>	TIME ACTIVE FROM <u>1430</u> TO <u>1433</u>			
NATURE OF TARGET (TO INCLUDE CALIBER) <u>HVY BTRY</u>				REMARKS (AREA SHELLS, CONTROL) <u>55187197</u>			CONC NR <u>EE1</u>		

DA FORM 6-4

REPLACES EDITION OF 1 MAR 55, WHICH IS OBSOLETE

Figure 69. Completed DA Form 6-4.

88. Mean Intervals for Several Records

If several records are obtained of sound waves from one sound source or from a closely grouped series of sound sources in a very short period of time, it is not necessary to complete a sound plotting record (DA Form 6-4) for each sound ranging record. Compare the corresponding initial time intervals for the several records to see if they agree to within a few thousandths of a second, and then average them to obtain a set of mean time intervals. Apply corrections (weather and curvature) to the mean time intervals and make a corrected plot of the sound source.

89. Calculator Method of Applying Weather Corrections

a. General. A calculator (either electrical or mechanical) can be used to apply temperature and wind corrections to initial time intervals, thereby allowing the automatic determination of weather-corrected time intervals without constant recourse to correction charts. The calculator method is the most rapid and preferred method of processing time intervals. If this method is to be used in conjunction with a straight regular base, two calculators will be required, one for plus time intervals and one for minus time intervals. If this method is to be used in conjunction with any other type of base, more than two calculators will be required; the total number necessary will depend on the configuration of the base. The calculator method is based on the principle that the time interval recorded for any length of subbase may be converted to the time interval which would have been recorded had the subbase been 4 sound seconds in length. The calculators are used to perform the following four steps in the processing of time intervals:

- (1) Convert the recorded time interval to a 4-second equivalent.
- (2) Apply the temperature correction.
- (3) Apply the wind correction.
- (4) Compute the weather-corrected time interval.

b. The 4-Second Equivalent. The conversion of the recorded time interval for a subbase length other than 4 sound seconds to the time interval that would have been recorded for a

4-second subbase is called determining the *4-second equivalent*. Assuming that a time interval T has been recorded for a subbase S in length and the plotting fan has a time interval scale devised for a subbase X in length, then, $\frac{X}{S} \times T$ is the time interval that must be plotted

with the fan. For example, if a time interval of 1.0 second is recorded for a 2-second subbase, the proper time interval to plot with a 4-second

plotting fan is 2.0 seconds ($\frac{4}{2} \times 1.0$). Since the

function of converting the time interval is carried out automatically when the calculator method is used, only 4-second time interval scales are used in plotting.

c. Plotting Charts for the Calculator Method. Construct the preliminary plotting chart as described in paragraph 75a. Construct the final plotting chart as described in paragraph 76a. On both the preliminary and final plotting charts, however, the 4-second time interval scale is used to plot time intervals.

d. Curvature Corrections for the Calculator Method. To obtain curvature corrections from the curvature correction chart for use with the calculator method, utilize the procedures described in paragraph 86, but enter the chart with a 4-second subbase value. To use the curvature correction template on the preliminary chart, follow the procedures described in paragraph 73.

e. Preliminary Computations. To process time intervals by the calculator method, it is first necessary to perform two preliminary computations to arrive at the temperature-time conversion factor and the wind correction. The results of the computations are placed on the calculators to allow automatic processing of time intervals.

- (1) *Computing the temperature-time conversion factor.* The temperature-time conversion factor is used to convert the time interval to a 4-second equivalent and to apply the temperature correction in a single operation. To compute the temperature-time conversion factor, apply the following formula:

Conversion number

Length of subbase (meters)

= temperature-time conversion factor.

To determine the conversion number, enter table V, appendix II, which lists a conversion number for each degree of temperature from -70° F. to $+140^{\circ}$ F. The temperature-time conversion factor is computed to four places and then rounded off to three places.

- (2) *Example.* Effective temperature (latest meteorological message) = $+85^{\circ}$; subbase length = 1,250 meters; and conversion number (from table V, app II) = 1396.0.

Conversion number = 1396.0
Length of subbase = 1,250
 $\frac{1396.0}{1,250} = 1.1168 = 1.117$
(rounded to three places).

- (3) *Determining the wind correction by using a subbase value of 4 seconds in all cases.* Determine the wind correction in the usual manner for the particular type of base being employed.

f. Preparing the Calculators. (All procedures shown are for use with the Monroe hand-operated, nonlisting, eight-column computer.) Enter the wind correction on each calculator in the following manner:

- (1) Shift the carriage to the extreme left position.
- (2) Establish a decimal point on the keyboard between columns 3 and 4 (counting from the right).
- (3) Place a decimal marker between windows 6 and 7 on the lower carriage row.
- (4) Place a decimal marker between windows 3 and 4 on the upper carriage row.
- (5) Aline the decimal marker on the lower carriage row directly above the decimal marker on the keyboard.
- (6) Clear both carriage rows and the keyboard.
- (7) Punch the figure for the determined wind corrections (*e*(3) above) on the keyboard and crank the figure onto the lower carriage row.

- (8) If the wind correction has a plus sign, turn the operating crank of the calculator designated to process plus time intervals forward (away from the operator) and the operating crank of the calculator designated to process minus time intervals backward.

- (9) If the wind correction has a minus sign, reverse the process described in (8) above.
- (10) Clear the *upper* carriage row only.
- (11) Depress the R (repeat) button on the keyboard.
- (12) Punch the figure for the determined temperature-time conversion factor (*e*(1) above) on the keyboard, using the decimal point established in (2) above.
- (13) The calculators are now prepared to process time intervals. Do not operate carriage clearing cranks in either direction until ready to clear the machines preparatory to setting up operations for a new set of meteorological conditions.

g. Processing Time Intervals. Process time intervals on the calculators prepared as described in *f* above, as follows:

- (1) Process each plus time interval on the calculator designated for plus time intervals; process each minus time interval on the calculator designated for minus time intervals.
- (2) Turn the operating crank so that the figure for the initial time interval appears in windows 4, 3, 2, and 1 of the upper carriage row. The weather-corrected 4-second equivalent will appear in windows 7, 6, 5, and 4 of the lower carriage row. Round off the figure by the number appearing in window 3.
- (3) Process succeeding time intervals by tuning the operating crank until each new initial time interval appears on the upper carriage row.
- (4) *Do not change the wind correction or the factor settings until a new meteorological message is received.*

h. Special Case of Processing Time Intervals. When the wind correction is opposite in sign

to, and greater in absolute value than, the temperature-corrected 4-second equivalent, a series of 9's will appear on the lower carriage row; in this case, the initial time interval will be processed as follows:

- (1) Process the initial time interval on the calculator designated for time intervals of the *opposite* sign.
- (2) Turn the operating crank backward until the initial time interval appears in *red* on the upper carriage row.
- (3) Read the weather-corrected 4-second equivalent time interval as in *g*(2) above.
- (4) The weather-corrected time interval takes the sign of the calculator on which it is processed.

90. Special Modifications of the Calculator Method

When used in conjunction with other than straight regular bases, the calculator method of applying weather corrections requires more than two calculators; however, the following modifications of the calculator method reduce the number of calculators required.

a. Curved Regular Bases. To use the calculator method with curved regular bases, process initial time intervals as described in paragraph 89, but *do not* set the wind correction on the calculator. Use a single calculator to arrive at the temperature-corrected 4-second equivalent. Determine the wind corrections for each subbase, using the 4-second subbase value, and add the wind correction algebraically to each temperature-corrected 4-second equivalent time intervals read from the calculator.

b. Irregular Bases.

- (1) When each subbase of an irregular sound ranging base is different in

length and azimuth, the use of the standard calculator method is not practical because calculators in excess of TOE authorization would be required (5 calculators, 1 for each subbase, would be required for a 6-microphone base). For this type of irregular base, time intervals are processed as in *a* above.

- (2) When all subbases are equal in length but one or two subbases are irregularly alined, a small *additional* wind correction can be computed for the misalined subbases and applied separately to the time intervals recorded for those subbases.
- (3) When one subbase of a six-microphone base is different from the other four but all are alined, an additional calculator may be used to convert initial time intervals recorded for the non-common subbase to equivalents of the time intervals recorded for the *common subbases*. All the time intervals are then processed on the two calculators prepared for the subbases of common length. For example, four subbases are 1,200 meters long and the fifth is 1,500 meters long. A time interval of 2.5 seconds is recorded for the 1,500-meter subbase. Time intervals of 2.0 seconds are recorded for the 1,200-meter subbases. The 2.5-second time interval is multiplied by $1200/1500$ to convert it to a 2.0-second time interval. The 2.0-second time intervals are then processed on the two calculators prepared for the 1,200-meter subbases.

CHAPTER 13

PLOT INTERPRETATION

91. General

Even if survey of the sound ranging base is accurate and weather and curvature corrections have been applied, a point plot (*P* plot), one on which all the rays of a sound ranging plot intersect at one point, is seldom obtained since exact corrections cannot be made for the atmospheric effects on sound wave travel paths. Instead, the intersecting rays form a polygon, called *the polygon of error* (fig. 74).

92. Plot Analysis

a. Appearance of the Plot. A point plot is not necessarily an accurate plot. Instead, a plot on which the intersecting rays form a polygon, thereby reflecting the effects of many different factors, will, in many instances, be more accurate than a point plot.

b. Accuracy Factors. In addition to the appearance of the plot, the following factors must be considered in analyzing the accuracy of the plot:

- (1) *Survey accuracy.* A constant survey error which occurred throughout the surveying of the microphone positions may displace the entire plot in one direction or another without appreciably enlarging the polygon of error; however, survey errors which are not constant result in a larger polygon of error.
- (2) *Weather conditions.* The application of weather corrections frequently enlarges the polygon of error while improving the accuracy of its position. Some weather conditions are favorable and some are unfavorable for sound travel and sound ranging (para. 10).
- (3) *Length of base.* A longer overall base length will generally increase the accuracy of the plot. For example, a base with 4-second subbase will gen-

erally produce a more accurate plot on a sound source at a distance of 10,000 meters than a base with 3-second subbases.

- (4) *Distance to the sound source.* In most instances, the greater the distance to the sound source, the less accurate is the plot.
- (5) *Readability of the record.* An obscure or indefinite record with poor reading points will introduce inaccuracies in the plot.

c. Large Polygons of Error. A large polygon of error may indicate a specific type of error. The following characteristics in a plot may indicate the source of error:

- (1) *Flank ray widely divergent.* A widely divergent flank ray may indicate an error in plotting the ray from a flank midpoint. The error in plotting is frequently caused by an error in reading the break on the sound ranging record of a flank microphone. A widely divergent flank ray may also indicate an error in computing or plotting a time interval.
- (2) *One (or two) widely divergent rays.* One or two widely divergent rays may be caused by an error in sound reception due to a terrain obstruction (a hill or large building).
- (3) *Two rays equally divergent in opposite directions.* Two rays equally divergent in opposite directions indicate an error in reading the break on the sound ranging record of an interior microphone. (An error in computing or plotting a time interval will affect only one ray.)
- (4) *Similar distortion in successive plots.* Similar distortion in plots for all sound sources may indicate an error in survey.

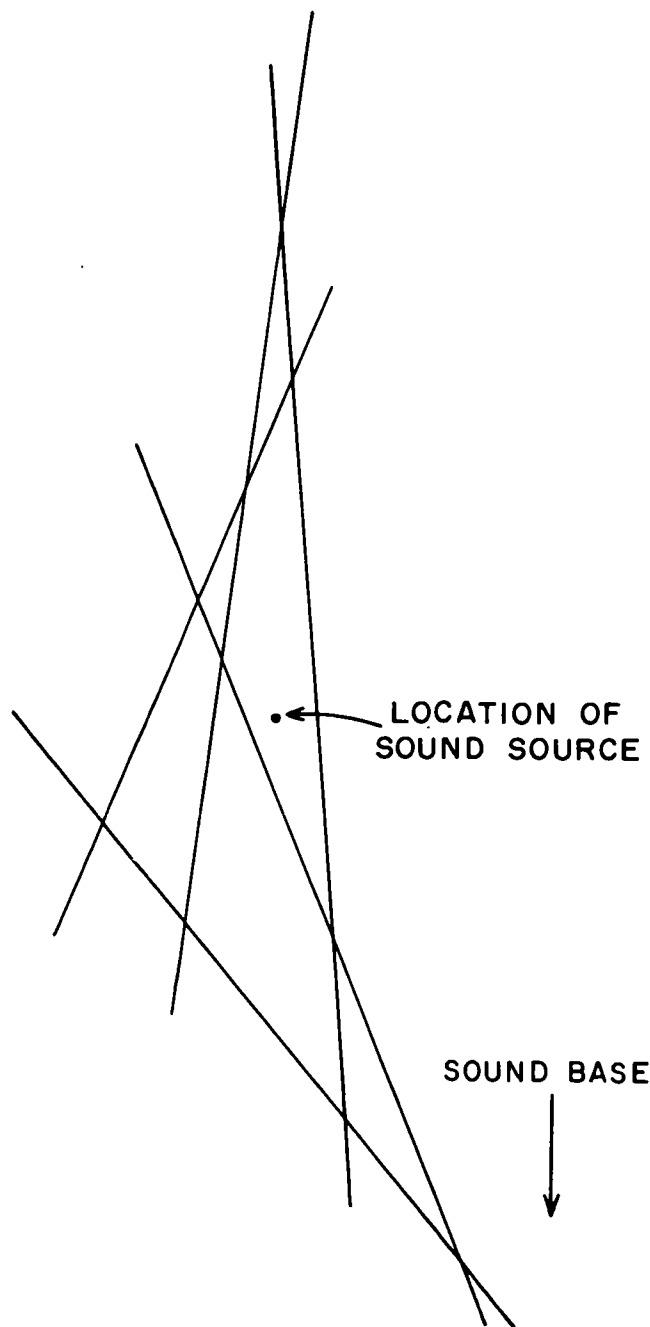


Figure 70. The polygon of error.

- (5) *Radical changes in succeeding polygons.* Any radical changes in the appearance of plots in the same general area may indicate an unusual change in the weather.

93. Determination of the Center of the Polygon

a. General. The polygon of error must be evaluated to determine the location of the sound source as accurately as possible. If the polygon

b. Determination by Computation. If the sound ranging plot is made on a gridded chart, determine the center of the polygon of error by—

-
- The diagram illustrates the relationship between the arithmetic mean (A), harmonic mean (H), and geometric mean (G) for two numbers. A vertical line segment AB is shown. A horizontal line segment AC is drawn from A to a point C on the extension of AB . A point L is marked on AB such that $AL = \frac{1}{2} AB$. A point G is marked on AB such that $AG = \frac{1}{3} LC$. A dashed line segment connects L and C . A point H is marked on the segment LC such that $LH = \frac{1}{3} LC$. A curved line segment connects A and H , labeled "MEAN".

96

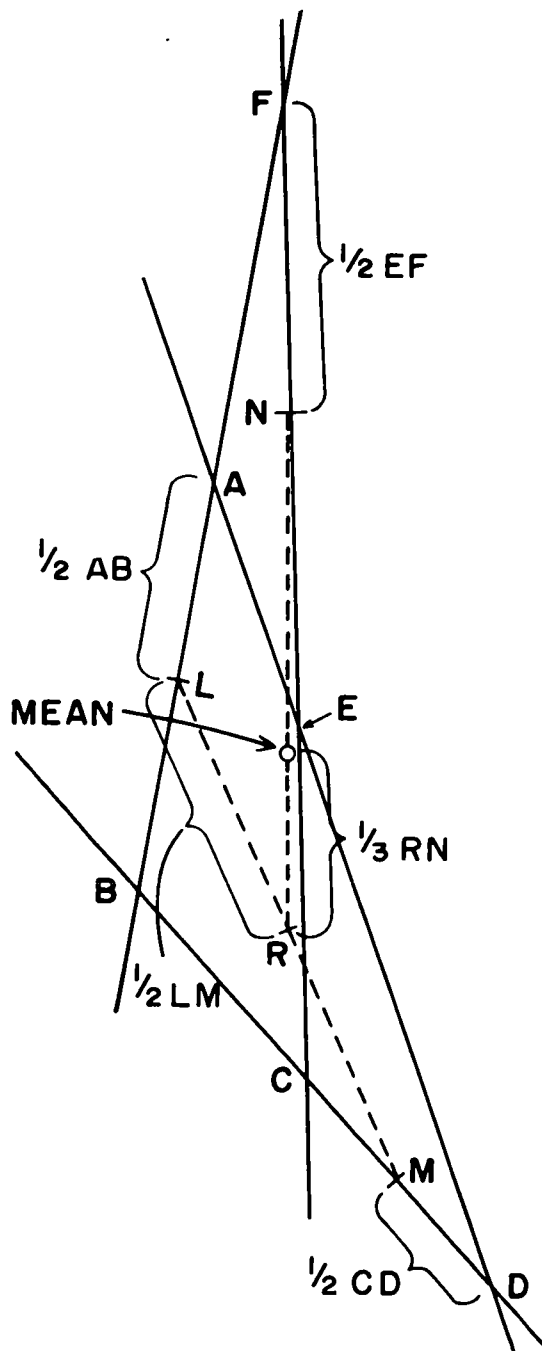


Figure 72. Constructing the center of a polygon (four-ray plot).

plot; 6, in a four-ray plot; and 10, in a five-ray plot).

- (2) Averaging the easting and northing coordinates of all intersections to obtain a mean location of the ray intersections. This mean location is the computed center of the polygon.

c. Determination by Construction. To construct the center of a polygon, group all intersections into pairs and plot a point midway between each pair. Group the plotted midpoints into pairs and plot additional midpoints between each pair. Continue this procedure until it is possible to plot one final midpoint. In

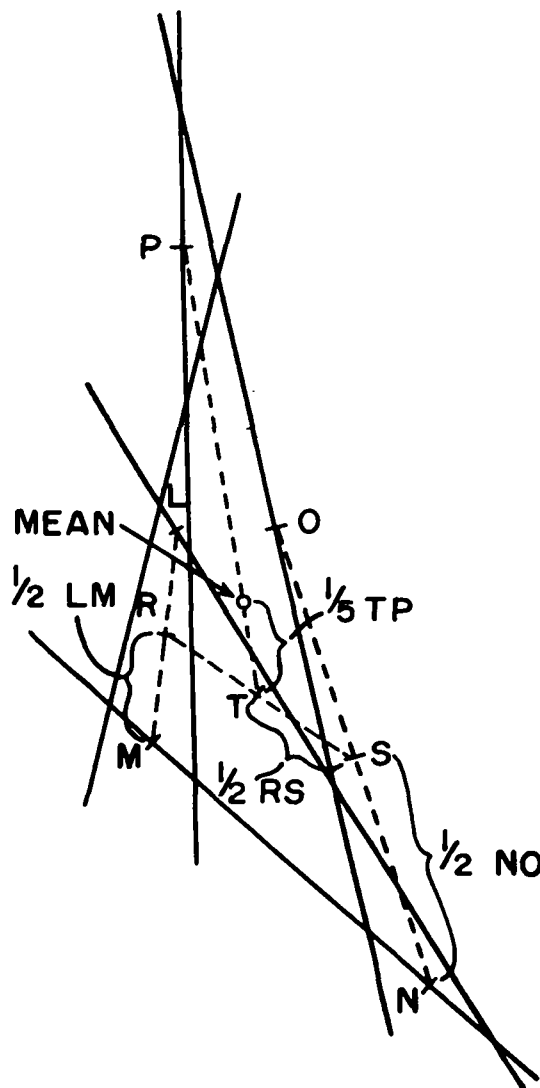


Figure 73. Constructing the center of a polygon (five-ray plot).

grouping the intersections into pairs, use each intersection only *one* time. When plotting midpoints between a pair of intersections which have a different number of intersecting rays, weigh the importance given to each intersection in proportion to the number of intersecting rays; for example:

- (1) *Three-ray plot.* In a three-way plot (fig. 71), plot a midpoint between two of the three intersections (A and B) and then plot a mean point one-third of the distance between the midpoint and the third intersection (C).
- (2) *Four-ray plot.* In a four-ray plot (fig.

72), plot the midpoints (L, M, and N) between each of the three pairs of intersections (AB, CD, and EF). Find the mean point of the three plotted midpoints in the same manner as in a three-ray plot ((1) above).

- (3) *Five-ray plot.* In a five-ray plot (fig. 73), group the 10 intersections into pairs and plot the midpoint of each pair (L, M, N, O, and P). Group the five resulting midpoints into two pairs, leaving one odd midpoint (P), and plot the midpoint of these two pairs (R and S). Then plot the mid-

point T between R and S. Finally, find the center of the polygon on a line between points T and P, one-fifth of the total length of the line from T to P. The center is found one-fifth of the length of the line from T because T is the mean result of 8 of the 10 intersections, whereas P is the result of only 2 of the 10 intersections.

94. Estimation of Accuracy

a. The estimated accuracy of a sound ranging location is expressed as the number of meters that the sound ranging location of the sound source is expected to vary from the actual location of the sound source. That is, if an estimated accuracy of 100 meters is given, the sound ranging location is believed to fall within 100 meters of the true location. The estimate of accuracy is based on the following factors:

- (1) Appearance of the polygon of error.
- (2) Assumed or computed accuracy of the survey.
- (3) The length of the sound base compared with the distance to the sound source.
- (4) Weather conditions.

- (5) Readability of the sound ranging record.
- (6) Terrain over which the sound wave traveled and on which the sound base is located.
- (7) Training of personnel.
- (8) Condition of equipment.

b. Under good sound ranging conditions, sound platoons can locate hostile artillery with an accuracy of 0 to 150 meters at distances up to twice the base length. Beyond this, the accuracy depreciates. The distance at which locations can be made is dependent on the intensity of the sound.

c. A sound ranging location is generally more accurate in direction (measured parallel to the sound base) than it is in distance (measured perpendicular to the sound base). A reported accuracy of 50 meters may represent a possible error of 40 meters in distance but only 30 meters in direction.

d. The accuracy of a sound ranging location is expressed as being within 50 meters, within 100 meters, within 150 meters, or over 150 meters.

CHAPTER 14

SOUND RANGING EQUIPMENT AND PERSONNEL

Section I. GENERAL

95. Equipment

The equipment necessary for recording the microphone detections, evaluating the record, and plotting the location of the sound source is located at the sound ranging command post. This equipment includes the sound ranging set, with the cable and radio communications required between the set and the microphones of the sound base and between the set and the observation post; record reading tools; and the plotting and correction charts and devices. In addition, cable and radio communications are established with higher and adjacent echelons.

96. Personnel

The personnel of the sound CP are organic to the sound platoon and the target acquisition battery communication platoon. Sound platoon personnel operate the sound recording, evaluating, and plotting devices and the communications connected directly with the sound ranging functions. The communication personnel of the CP install and maintain the communications but are not responsible for their operation.

Section II. GENERAL DUTIES OF PERSONNEL

97. General

Only the duties of the sound platoon personnel in the operation of the sound CP and OP's will be discussed in this chapter. The duties of the communication personnel are discussed in detail in FM 6-120.

98. Duties of the Sound Platoon Commander

The sound platoon commander directs and supervises the work of all personnel in operating the sound ranging command post. His specific duties are to—

- a.* Determine which records will be evaluated by the record readers.
- b.* Estimate the accuracy of the locations made or delegate this duty to some other member of the team.
- c.* Check the work of each member of the team to determine the effectiveness of operations.
- d.* Inform the communication personnel of the communication maintenance requirements and of requirements for additional communication channels.

99. Duties of the Sound Chief

The sound chief assists the sound platoon commander, acts as his relief, and assumes his duties in his absence.

100. Duties of the Chief Sound Recorder and Sound Recorders

- a.* The chief sound recorder—
 - (1) Supervises the training of the sound recorders and their performance of duty.
 - (2) Operates the sound recording set.
 - (3) Remains in constant contact with the observers at the OP's and informs them to release the outpost switch after the sound wave arrival time has been recorded by the sound recording set.
 - (4) Requests the observers' reports when they are ready to receive them and writes the data contained in the reports on the face of the sound ranging record concerned.

- (5) Records and forwards any battlefield information reported by the observers.
- (6) Relays messages from the sound platoon commander to the observers.
- (7) Continually checks the operation of the sound recording set and performs necessary minor adjustments which can be made without stopping sound recording operations.

b. The sound recorders perform the duties performed in *a*(2) through (7) above.

101. Duties of the Chief Record Reader and Record Readers

a. The chief record reader—

- (1) Supervises the training of the record readers and their performance of duties.
- (2) Determines the pattern of arrivals at the microphones from the OP data recorded on the face of the sound ranging record.
- (3) Places the record in a record reading tool and reads the arrival time at each microphone (as these times are announced, they are recorded by another member of the sound platoon team).

b. The record readers perform the duties outlined in *a*(2) and (3) above.

102. Duties of the Sound Plotter and the Draftsmen-Plotters

a. The sound plotter—

- (1) Supervises the training of the draftsmen-plotters and their performance of duties.
- (2) Plots the weather-corrected time intervals on an ungridded plotting chart with the plotting fan.

- (3) Examines the resulting intersections, determines the approximate location of the sound source, and reads and records the distance from each midpoint to this location.
- (4) Plots the final corrected time intervals on a gridded plotting chart, using the appropriate plotting device (ch 11).
- (5) Evaluates the resulting plot of the sound source location, using methods described in paragraphs 92 and 94.
- (6) Records the grid reference of the sound source on the Sound Plotting Record, DA Form 6-4.

b. The draftsmen-plotters perform the duties performed in *a*(2) through (6) above.

103. Duties of the Sound Computer

The sound computer—

- a.* Computes the initial time intervals.
- b.* Computes weather-corrected time intervals by using the calculator method (para. 89) or correction devices (para. 83 and 84) and records them on the sound plotting record.
- c.* Determines the curvature correction, using the weather-corrected time intervals and the distances from each midpoint to the approximate location of the sound source together with the proper correction device (para. 86).

d. Records the corrections on the Sound Plotting Record, DA Form 6-4, and computes the final corrected time intervals.

104. Duties of the Senior Sound Observer, the Sound Specialist, and the Sound Observers

The senior sound observer, the sound specialist, and the sound observers are normally located at the OP's while the CP is in operation. For a discussion of their duties during operation of the CP, see paragraphs 47 and 48, and chapter 9.

Section III. SOUND RANGING COMMAND POST OPERATIONS

105. General

Basically, two types of sound ranging operations take place at this sound ranging CP; both involve sound recording and record reading. In one operation, corrections are applied, and a grid or corrected, location of the sound source

is obtained; in the other operation, no corrections are applied, and a relative location of the sound source is obtained. The corrected location is the most frequently used and results in a sound source location which can be used by all echelons on the common grid. The relative

location is used only in adjusting artillery fire on a target by sound ranging methods.

106. Corrected Location Operations

a. Starting with the moment that a sound ranging record is made, the following operations occur at the CP, resulting in the corrected location of the sound source:

- (1) The sound recorder removes the record from the sound ranging set, assigns it a serial number, records the observer's report on the face of the record, and passes the record to the record reader.
- (2) The record reader determines the pattern of breaks, places the record in the record reading tool, and reads the arrival times aloud.
- (3) A computer records the arrival times and computes the time intervals on the sound plotting record. The record reader then removes the record from the record reading tool while the computer passes the sound plotting record to another computer.
- (4) The second computer determines temperature and wind corrections, records these corrections on the sound plotting record, computes the weather-corrected time intervals, and then passes the sound plotting record to a draftsman-plotter.
- (5) The draftsman-plotter plots the weather-corrected time intervals, selects the approximate sound source location, reads the distance from each midpoint to this approximate location, records these distances on the sound plotting record, and passes the sound plotting record to a third computer.
- (6) The third computer determines the curvature corrections, records them on the sound plotting record, computes the final corrected time intervals, and then passes the sound plotting record to a second draftsman-plotter.
- (7) The second draftsman-plotter plots the final corrected time intervals, evaluates the polygon of error for the sound source location, reads the grid reference of this location, and records

this grid reference on the sound plotting record along with the estimation of accuracy assessed by the sound platoon commander (or by the person to whom he has assigned this duty).

- (8) The grid reference of the sound source location is then reported to the next higher echelon or to another echelon, as directed.

b. Figure 74 illustrates a type organization for a sound ranging CP to perform the operations described in *a* above. The organization shown is based on the assumption that all-sub-base correction charts will be used to compute wind and curvature corrections. If one of the other correction methods is used, the organizational and operational procedure must be modified to fit that method. The organization shown in figure 74 is suited for short periods of operation; some of the duties must be combined for 24-hour operation. The type of organization used will depend on the number of personnel available for duty and the periods of greatest activity. A typical reduced strength organization may consist of—

- (1) *A sound recorder*, who will carry out his normal duties.
- (2) *A record reader*, who will carry out his normal duties and also assist the computer.
- (3) *A computer*, who will carry out his normal duties and also act as the computer who records arrival times.
- (4) *Two draftsman-plotters*, who will carry out their normal duties and act as computer. (If necessary, the duties of one draftsman-plotter may be performed by the sound platoon commander, the sound chief, or the person in charge of the sound ranging CP at the time.)

107. Relative Location Operations

a. Starting with the moment that a sound ranging record is made, the following operations occur at the CP, resulting in the relative location of the sound source:

- (1) The sound recorder removes the record from the sound ranging set, assigns it a serial number, records the observer's report on the face of the

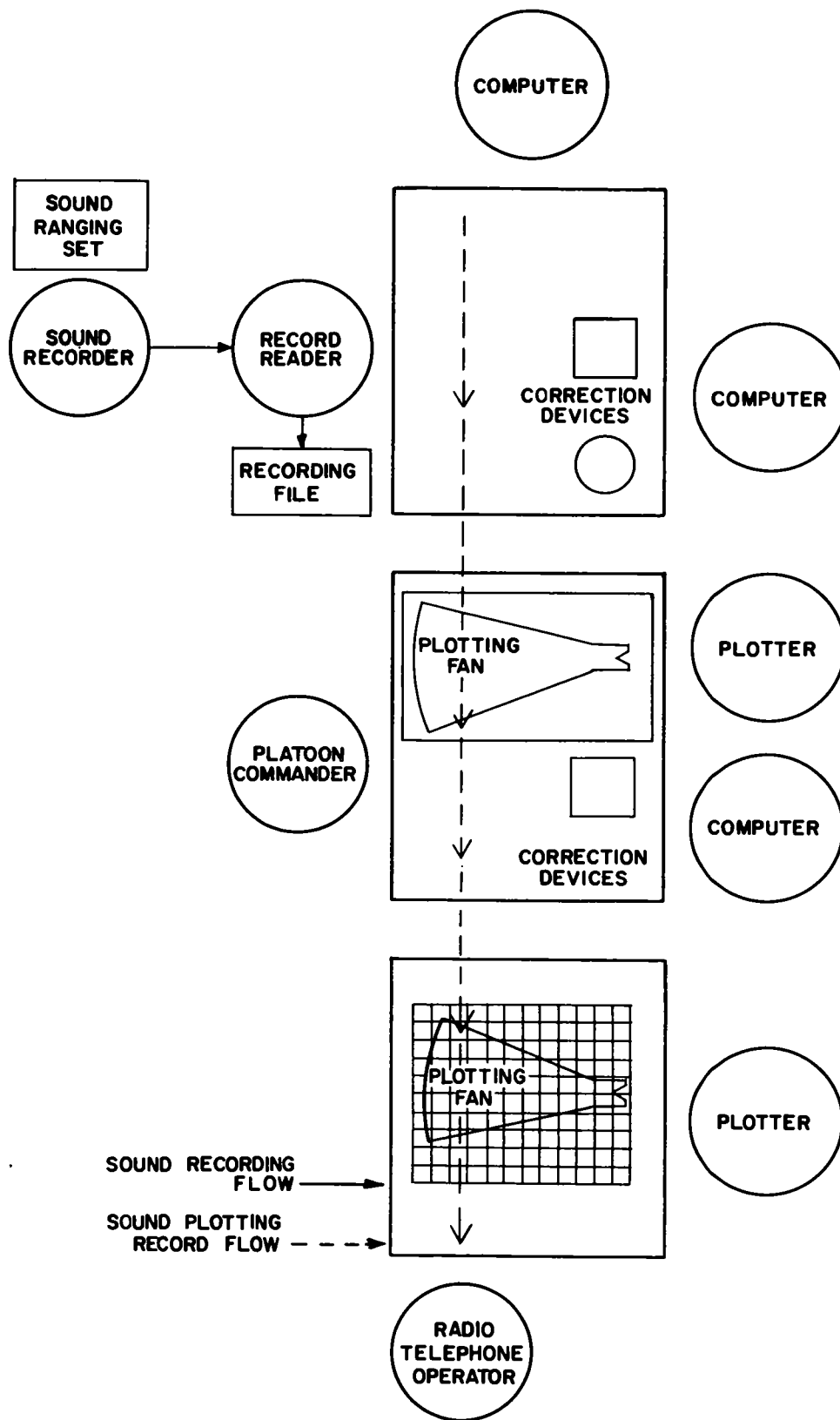


Figure 74. Organization of a type sound ranging CP.

record, and passes the record to the record reader.

- (2) The record reader determines the pattern of breaks, places the record in the record reading tool, and reads the arrival times aloud.
- (3) A computer records the arrival times and computes the time intervals on the sound plotting record. The record reader then removes the record from the record reading tool while the computer passes the sound plotting record to a draftsman-plotter.
- (4) The draftsman-plotter plots the uncorrected time intervals on either a

blank or gridded chart, evaluates the polygon of error for the sound source location, and reads the displacement of the sound source location from the point to which relative readings are desired.

- (5) The amount of displacement is reported to the next higher echelon, as directed.

b. Since no corrections are applied in this operation, ample personnel are provided in the sound platoon to carry out this operation for indefinite periods of time. Normally, operations for both corrected and relative locations are carried on concurrently.

CHAPTER 15

BALLISTIC PLOTTING

108. General

a. When a weapon having a muzzle velocity greater than the speed of sound is fired, a double report is heard within a certain region on each side of the line of fire. One report, the *gun wave* (dull boom), originates at the muzzle and spreads out with a motion of uniform expansion. The other report, a *ballistic wave* (sharp crack), is generated by the projectile in the air as long as it moves along its trajectory at a velocity greater than that of sound. The ballistic wave is the result of the compression wave formed in front of the projectile and is similar to the bow wave of a ship moving through water.

b. The ballistic wave reaches the observer before the gun wave since it is produced by a projectile moving through the air at a velocity greater than that of sound. It is of higher pitch (frequency) and is sharper, louder, and clearer than the gun wave but usually contains less energy than the gun wave. Sound ranging microphones will detect the arrival of the ballistic wave. Although the ballistic wave alone is of no value in sound ranging, it may be used in conjunction with the shellburst wave to determine the line of fire of a weapon. This factor is important since the gun wave may not have been detected because of the extreme distance to the hostile weapon, adverse meteorological conditions, multiple arrivals, or other causes.

109. Generation of the Ballistic Wave

a. *General.* A projectile in its flight produces pressure disturbances which are propagated at the speed of sound. Figure 75 depicts the successive positions of a projectile in flight at 1-second intervals. The disturbance created by the projectile when it was at point A has been spreading outward for 5 seconds; therefore, the disturbance is represented by a circle with a

radius equal to the distance traveled by sound in 5 seconds. Similarly, the disturbance created at point B is represented by a circle with a radius equal to the distance traveled by sound in 4 seconds; at point C, by a circle with a radius equal to 3 seconds, and so on. Since the projectile is traveling faster than sound, a wave formed at a given point on the trajectory will overlap other waves formed at earlier points of origin. For example, the wave formed at point B will overlap the wave formed at point A; the waves will reinforce each other along a line tangent to all the waves. The resulting ballistic wave is the envelope (cone) of a system of spherical wave fronts.

b. *Shape of the Ballistic Wave.* As the velocity of the projectile gradually decreases, the ballistic wave changes from the cone shape (fig. 75) to a curved shape (fig. 76). After the velocity of the projectile drops to below that of sound, no further generation of the ballistic wave occurs but the wave already formed continues on ahead of the gun wave (fig. 76).

c. *Zone of Audibility.* The ballistic sound wave is apparent to an observer only in a certain area ahead of the weapon. An observer in one location may hear the ballistic sound wave, whereas another observer located in the same general vicinity may not. This situation is caused by the characteristic cone shape of the ballistic wave and the merging of the gun wave and the ballistic wave into one sound at certain points displaced right and left of the line of fire. The points at which this merging takes place depend on the velocity of the projectile.

110. Characteristics of the Ballistic Wave

a. The ballistic wave is of higher frequency than the gun wave.

b. On the sound ranging record, the ballistic wave break will normally precede the gun wave break by a short time. It may, however, occur

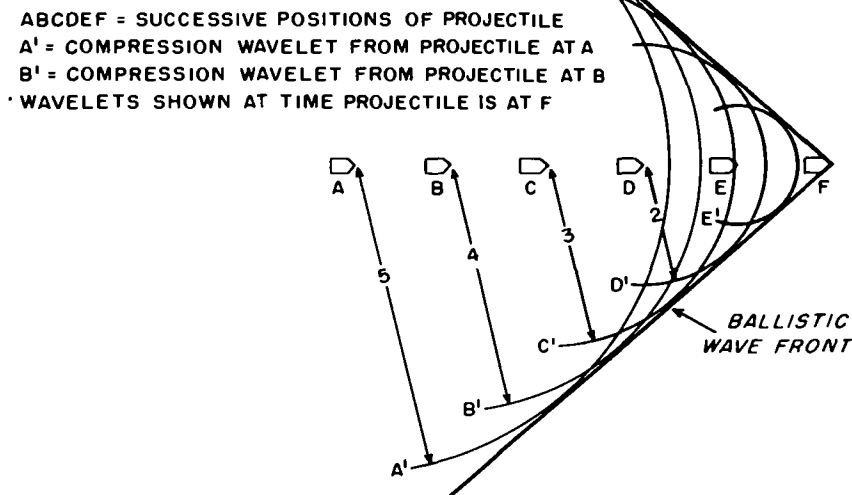


Figure 75. Generation of the ballistic wave.

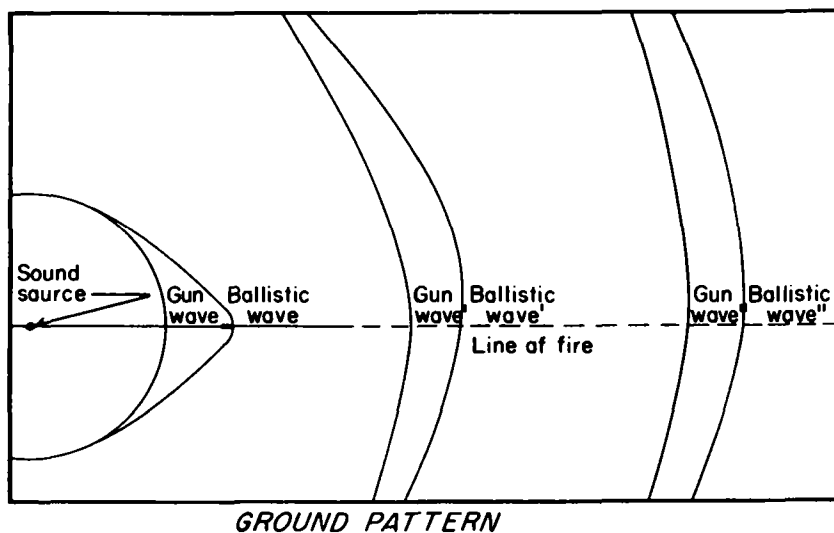


Figure 76. Travel of the ballistic wave.

at the time as the gun wave break.

c. Since the ballistic wave is propagated from a moving source, it originates closer to the sound ranging base than the gun wave; therefore, a ballistic wave break may be of greater amplitude than the corresponding gun wave break. Conversely, since the gun wave usually contains more energy, it may cause breaks of greater amplitude.

111. Relation of the Ballistic Wave to Sound Ranging

a. Favorable Considerations.

- (1) The recorded ballistic wave may be used to plot a line of fire (para. 112). The location of the hostile weapon may be determined by this procedure if the line of fire to one target can be plotted

in relation to another line of fire from the same weapon to a different target or in relation to any other line of direction to the hostile weapon, such as a shelling report azimuth or an azimuth from a single OP.

- (2) Under some conditions, an observer who may not be able to hear the gun wave might be able to hear the ballistic wave. When this situation exists, the observer can depress the outpost switch upon hearing the ballistic wave, and the microphones, consequently, may detect and cause to be recorded the gun wave which was inaudible to the observer. Also, the ballistic wave may alert the observer to listen carefully for a gun wave which might otherwise have been missed.

b. Unfavorable Considerations.

- (1) The ballistic wave break on the sound ranging record may distort the gun wave break on one or more traces.
- (2) The ballistic wave break on the sound ranging record may be mistaken for a gun wave break, resulting in a false sound source location or in no location at all.
- (3) Mistaking a ballistic wave for a gun wave may cause the observer to make a false estimate of the direction and distance to the hostile weapon since the origin of the ballistic wave is a moving source closer to the observer.

112. Plotting a Line of Fire

a. General. Times of arrival of the ballistic wave and the shellburst wave are read from

SHELL BURST									
RECORD NUMBER		SOUND PLOTTING RECORD						DATE	
49		(FM 6-122)						19	
METRO MSG TIME	TEMPERATURE	CONVERSION NUMBER	SUBBASE	AZIMUTH	LENGTH	CALC. FACTOR	BASE LOCATION		
2100	58	OF	1-2	6	M	M	GRIERSON HILL		
WIND DIRECTION	WIND SPEED	WIND CORRECTION	3-4		M <td>M</td> <th colspan="3">BASE TYPE</th>	M	BASE TYPE		
820	10	MPH	4-5		M	M	6 MIC 4- SEC STRAIGHT		
			5-6		M	M			
TIME READINGS									
RESULTS TO (-)	22.989	19.883	17.633						
1 22.989	2 19.883	3 17.633	4 17.166	5 18.809	6 21.692				
RESULTS TO (+)				17.166	18.809				
	C 1		C 2		C 3		C 4		C 5
	-	+	-	+	-	+	-	+	-
TIME INTERVAL	3.106		2.250		0.467			1.643	2.883
TEMP. CORR. OR TEMP. CONVERTED TIME	0.024		0.018		0.004			0.013	0.023
WIND CORRECTION	0.037		0.037		0.037		0.037		0.037
SUB TOTALS							0.037	1.656	0.037
SUBTRACT								0.037	0.037
WEATHER CORRECTED TIME INTERVAL	3.167		2.305		0.508			1.619	2.869
CURVATURE CORRECTION	0.019		0.041		0.018			0.044	0.027
FINAL TIME INTERVAL	3.186		2.346		0.526			1.663	2.896
APPROXIMATE DISTANCE	4,200		3,200		2,600		2,900		3700
FROM (FILE NR) / TIME REPORTED	GRID REFERENCE		ACCURACY		TIME ACTIVE				
17 / 2119	52759543		100		FROM 2100 TO 2110				
	NATURE OF TARGET (TO INCLUDE CALIBER)		REMARKS (AREA SHELLLED, CONTROL)		CONC				
	1 / M / G				NR				

DA FORM 6-4

REPLACES EDITION OF 1 MAR 55, WHICH IS OBSOLETE.

①

Figure 77. Ballistic wave computations on DA Form 6-4.

BALLISTIC WAVE

RECORD NUMBER		SOUND PLOTTING RECORD						DATE	
METRO MSG TIME		TEMPERATURE	CONVERSION NUMBER	SUBBASE	AZIMUTH	LENGTH	CALC. FACTOR	BASE LOCATION	
49		2100	58 OF	1-2	4	M	M	GRIERSON HILL	
WIND DIRECTION		WIND SPEED	WIND CORRECTION	2-3	2	M	M	BASE TYPE	
820		10 MPH		3-4		M	M	6-MIC 4-SEC STRAIGHT	
				4-5		M	M		
				5-6		M	M		
TIME READINGS									
RESULTS TO (-)	M ₁ 3.891	M ₂ 2.320	M ₃ 1.292	1.450	2.569				
1	2M ₄ 0.984	3M ₄ 0.984	4M ₄ 0.984	5M ₄ 0.984	6M ₄ 0.984				
RESULTS TO (+)									
	C 1		C 2		C 3		C 4		C 5
	-	+	-	+	-	+	-	+	-
TIME INTERVAL		2.907		1.336		0.308		0.466	1.585
TEMP. CORR. OR TEMP. CONVERTED TIME		0.023		0.010		0.002		0.004	0.012
WIND CORRECTION									
SUB TOTALS									
SUBTRACT									
WEATHER CORRECTED TIME INTERVAL									
CURVATURE CORRECTION									
FINAL TIME INTERVAL		2.930		1.346		0.310		0.470	1.597
RADIUS IN METERS APPROXIMATE DISTANCE		990		454		105		159	540
FROM (FILE NO) / TIME REPORTED	GRID REFERENCE				ACCURACY		TIME ACTIVE		
17 / 2119							FROM 2100 TO 2110		
	NATURE OF TARGET (TO INCLUDE CALIBER)				REMARKS (AREA SHELLS, CONTROL)			CONC	
	1/M/G							NR	

DA FORM 6-4

REPLACES EDITION OF 1 MAR 58, WHICH IS OBSOLETE.

②

Figure 77—Continued.

the sound ranging record and recorded on separate DA Forms 6-4 (fig. 77). The shellburst is located in the manner described in *b* below. The ballistic wave is plotted in a manner designed to reproduce on the plotting chart the configuration of the ballistic cone (wave) which intersected the ground at the instant the cone struck the first microphone. A line bisecting the cone and extending from the shellburst plot into the target area is a line of direction passing near or through the sound source.

b. Location of the Shellburst. If the shellburst is in front of the sound base, its location is determined in the same manner as that of any sound source. If the shellburst is to the rear of the sound base, the observer must make special effort to determine this fact since the resulting plot may give no indication of this. When a straight sound base (with regular or

irregular subbases) is being used and the shellburst is to the rear of the sound base, that shellburst is plotted as though it were to the front and then the plot is transferred to the rear. The transfer is accomplished by striking arcs from any two convenient microphone or mid-point positions to the rear of the sound base. The arcs must be equal in radii to the distance from the positions to the shellburst plotted in front of the base. The intersection of the two arcs is the shellburst location to the rear of the sound base; this operation is referred to as mirror plotting. If an irregularly aligned sound base (irregular subbase azimuths) or a curved sound base is being used and the shellburst occurs to the rear of the sound base, the shellburst must be plotted to the rear of the base in the same manner as any sound source. Care must be taken in any of these operations to insure that

the proper shellburst wave is associated with its corresponding ballistic wave.

c. *Plotting the Ballistic Wave, Case Number 1.* When the path of the projectile (line of fire) passes over or can be extended over the sound ranging base, the ballistic wave is plotted in the following manner:

- (1) The time of arrival at the microphone which first detected the ballistic wave is entered on the sound plotting record, DA Form 6-4 (2, fig. 77) in the *time readings* section in the *results to (+)* spaces. These entries are preceded by the numerical designation of the microphone which first detected the ballistic wave. The time of arrival

at the other microphones is entered in numerical succession in the appropriately numbered spaces above the first entries. The difference between the two entries in each column are determined and entered in the plus (+) columns of the *time interval* space. These time intervals are corrected for temperature (para. 83) and the algebraic sums are entered in the plus (+) columns of the *final time interval* space. The wind correction is ignored since the ballistic cone being plotted occurred at the sound base or very near it, and the wind effect is negligible. The *approximate distance* space

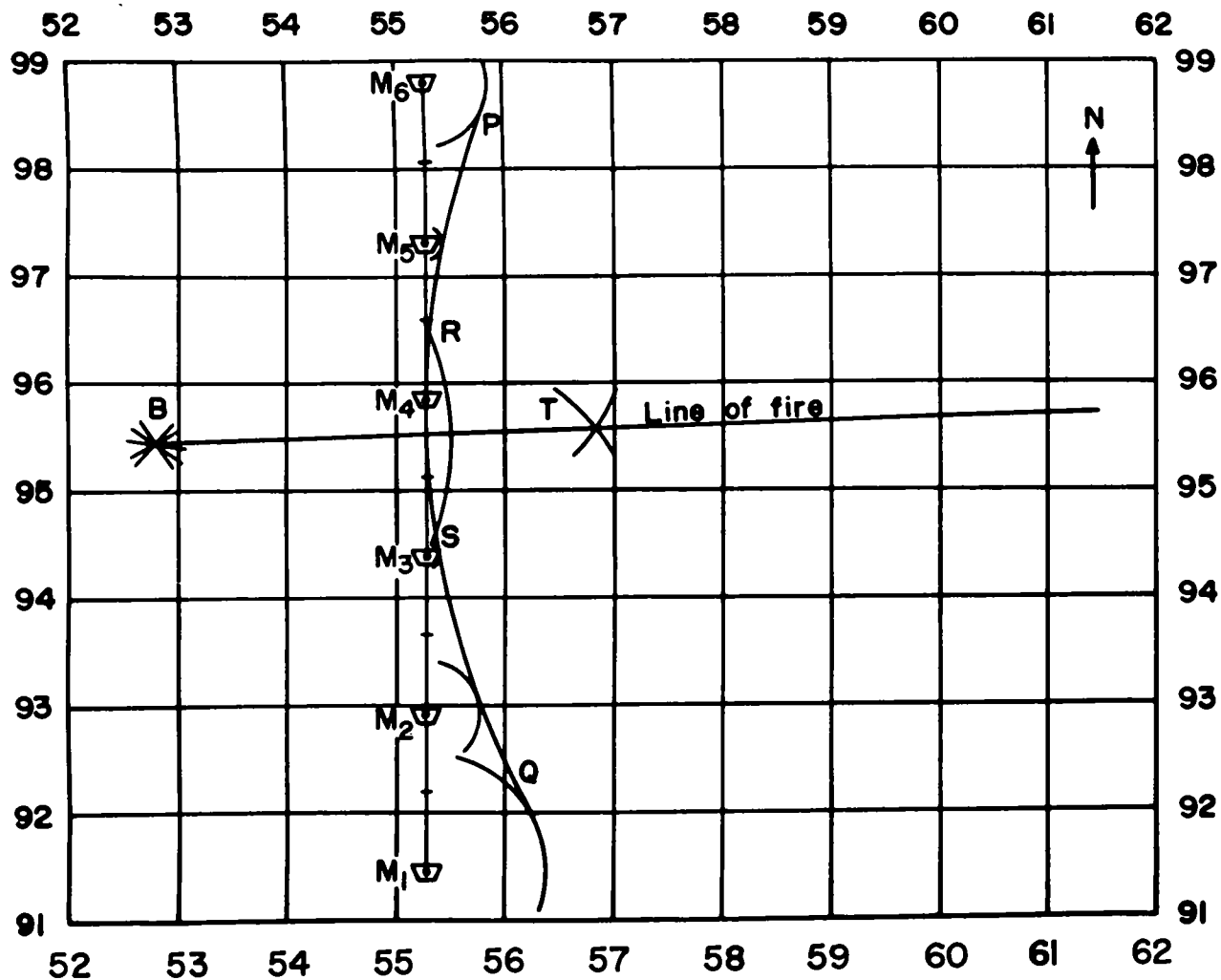


Figure 78. Line of fire determined from ballistic wave and shellburst wave, case number 1.

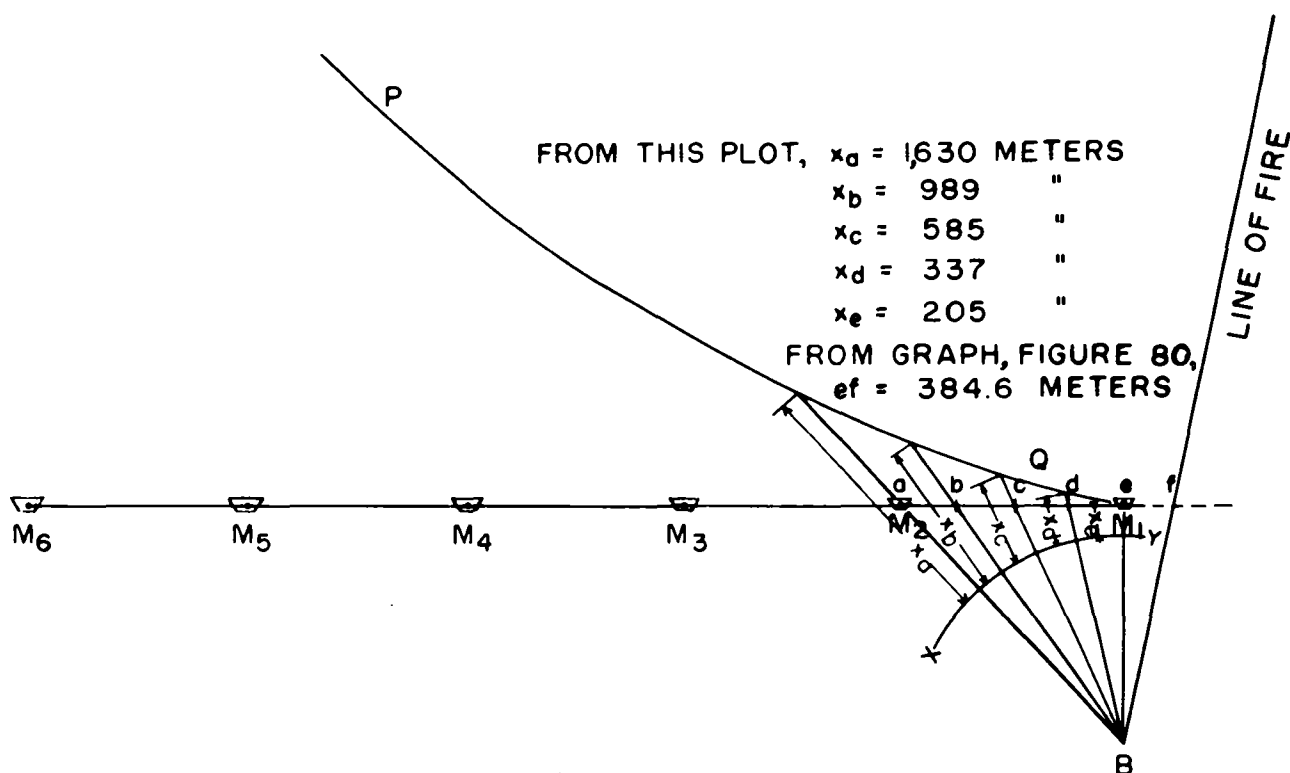


Figure 79. Line of fire determined from ballistic wave and shellburst wave, case number 2.

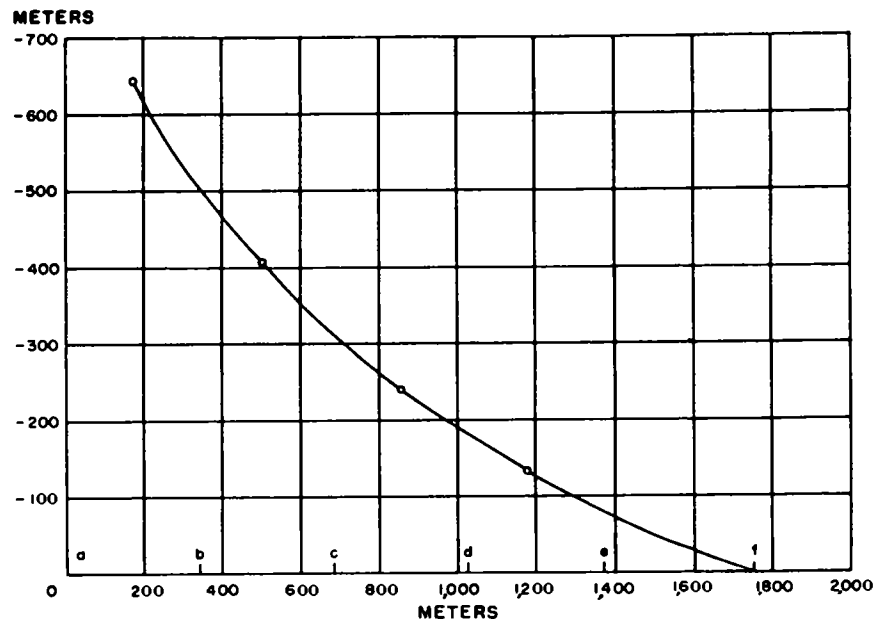
is changed to *radius in meters*, and the final time intervals are reduced to meters by multiplying by 337.6. The values so computed are entered in the columns of the *radius in meters* space.

- (2) On a plotting sheet (fig. 78) a compass is used to draw an arc in front of each *microphone* position with the corresponding radius as computed in (1) above. A flexible engineer's rule is used to produce a curve (PQ) tangent to all the constructed arcs and the zero-point microphone (the microphones which first detected the ballistic wave). Unless the line of fire is exactly centered on the zero-point microphone, the result will be a ballistic cone which slightly overlaps the sound base.
- (3) A compass is used to bisect the constructed curve (points R, S, and T) by using the shellburst plot (point B) as a focus. The shellburst and the point

of bisection (point T) are then connected by a line which is extended to the front of the sound base. This line is the line of direction to the sound source.

d. *Plotting the Ballistic Wave, Case Number 2.* When the path of the projectile, or its extension, does not cross the sound ranging base but passes within one subbase length of a flank microphone, the ballistic wave is plotted in the following manner (fig. 79):

- (1) The times of arrival are processed as in c(1) above, and a curve PQ is constructed as in c(2) above.
- (2) With the shellburst plot (point B) as a focus, a compass is used to draw an arc (XY) which approaches but does not intersect curve PQ; the radius is not critical. The subbase on the end, which curve PQ approaches, is then divided into four equal parts at points, b, c, and d by straight lines drawn from point B. The distance along each



FROM PLOT OF FIGURE 79

$$ab = bc = cd = de = 337.6 \text{ METERS}$$

$$x_b - x_a = -641 \text{ METERS}$$

$$x_d - x_c = -248 \text{ METERS}$$

$$x_c - x_b = -404 \text{ METERS}$$

$$x_e - x_d = -132 \text{ METERS}$$

$$\text{FROM GRAPH ABOVE: } ef = 1735 - 1350.4 = 384.6 \text{ METERS}$$

Figure 80. Graph for case No. 2.

of the lines from the arc XY to the curve PQ is scaled and recorded as x_a , x_b , x_c , x_d , and x_e . The differences along the segments ($x_a - x_b$, $x_b - x_c$, $x_c - x_d$, and $x_d - x_e$) are computed.

- (3) On a separate sheet, a graph is drawn with the line a-e and its intermediate points along the horizontal axis (fig. 80). The values of the differences between adjacent segments determined in (2) above are plotted along the vertical axis on the graph; e.g., $x_a - x_b$ is plotted above the midpoint of line a-b, $x_b - x_c$ is plotted above the midpoint of line b-c, $x_c - x_d$ is plotted above the midpoint of line c-d, and $x_d - x_e$ is plotted above the midpoint of line d-e. (Note that in this graph a larger scale may be used for distances along the vertical

axis than for distances along the horizontal axis.) A smooth curve is drawn through the four points and is extended until it cuts the horizontal axis at point f. The distance e-f is scaled off the graph.

- (4) The value of e-f in meters from the graph (fig. 80) is scaled off on the plotting chart (fig. 79) along an extension of the line a-e. The shellburst location (point B) (fig. 79) and point f are then connected by a line which is extended to the front of the sound base. This line is the line of direction to the sound source.

Note. If point f is more than one subbase length from the end microphone, the method outlined for case number 2 becomes inaccurate and should not be used.

CHAPTER 16

CONDUCT OF FIRE

113. General

Targets located by sound ranging are normally reported by grid reference, which allows any unit on the same grid system to fire on the located target. However, in certain instances, it will be desirable to adjust fire on the target located by sound ranging methods. Such instances occur when—

- a. The sound ranging base and the firing unit have no common survey control or are on different grid systems.
- b. No met data is available.

114. Capabilities and Limitations of Sound-On-Sound Adjustments

a. *Capabilities.* Sound-on-sound adjustments can be made quickly and accurately by utilizing target grid procedures even though meteorological data are not available, internal survey is approximate, and the sound ranging base is not on a common grid with the firing units. As few as four microphones can be used in sound-on-sound adjustments.

b. *Limitations.* The effectiveness of sound-on-sound adjustments is limited by—

- (1) *Time.* Since weather corrections are not applied during the adjustment, and adjustment must be performed rapidly in order to reduce the effects of weather changes.
- (2) *Range.* Since a shellburst wave has less energy than a muzzle wave, it cannot be recorded at as great a distance; therefore, the range at which the adjustment can be performed is limited.

115. Sound-On-Sound Adjustments

If the internal survey of the sound ranging base is approximate, all locations will be relative to some other point (usually a firing unit's registration point), and the words "will ad-

just" will follow the relative location of the target. The sound ranging adjustment discussed in *a* through *e* below is called a sound-on-sound adjustment and consists simply of adjusting the shellbursts until they plot on the plotted location of the target.

a. *Relative Locations.* When the internal survey is only approximate, when corrections are not applied, or when the chart location of the sound ranging base is not accurately known, locations of sound sources are determined relative to the location of some other sound source which has been plotted under identical or nearly identical weather conditions. For example, an enemy gun and a friendly shellburst located in the same general area within a short period of time will, although not located in their true grid position, have relatively the same inaccuracies due to weather and survey effects in their locations and thus will be *relatively* located properly. The distance between the two will be correct even though their grid position is not. This distance can be measured, and subsequent shellbursts can be moved or shifted to fall at the same point as the gun location.

b. *Conditions Required for Accuracy.* Relative locations are accurate only if no appreciable change in weather takes place from the time that an enemy gun is located until the shellburst is adjusted. The accuracy of the sound-on-sound method increases with improvements in survey and as the relative distance between the sound sources decreases.

c. *Procedure.* When one of the conditions described in paragraph 113 occurs and it is desirable to perform a sound ranging adjustment, the target is located by relative means; that is, it is plotted *without* corrections and is located relative to a friendly shellburst which is fired into the same area. If the sound ranging base and the firing unit are on the same grid system, the round is fired at the grid reference of

the uncorrected target plot; if they are on different systems, the firing unit is requested to fire one round in the general area of the target, either on a registration point or on a point selected by agreement of the firing unit and the sound ranging platoon. From the location of this round, a shift is measured to place the fire on the target.

d. Initial Fire Request. After a target has been located and it is decided that a sound-on-sound adjustment is to be performed, the sound ranging CP personnel transmit an initial fire request to the firing unit. The request is essentially the same as the forward observer's initial fire request as described in FM 6-40 with the following exceptions:

- (1) *Azimuth.* The azimuth is measured from a midpoint, usually C₁, to the target.
- (2) *Marking round(s).* If an ungridded chart is being used by the sound platoon, the firing unit is requested to fire a marking round at a point that is located on or can be located on the firing chart of the firing unit. The point designated should be in the vicinity of the target and must be so located that the sound platoon can locate the shellburst.
- (3) *Type of adjustment.* The firing unit is requested to fire one gun in adjustment to simplify record reading and to save time.
- (4) *Control. Time of flight and on the way* are requested so that the proper shellburst may be recorded.

Example: ALFA SOUND
FIRE MISSION
MARK REFERENCE POINT
AZIMUTH 3970
LIGHT ARTILLERY BATTERY FIRING
ONE GUN, ONE ROUND, AT
MY COMMAND
WILL ADJUST
REPORT TIME FLIGHT AND
ON THE WAY.

e. Conduct of a Sound-on-Sound Adjustment. To fire mission is conducted as follows:

- (1) The firing unit fires one round, using the date given in the initial fire re-

quest (*d* above). The location of the point of impact is determined using normal sound ranging methods, but without applying corrections. During the operation a plotter may adjust one or more of the normals if a large polygon of error exists (para. 79). The adjustment of the normals must be performed during the initial location of the target; the adjusted normals are used throughout the adjustment of fire on the target.

- (2) Using the meters side of a coordinate scale, the plotter determines the shift from the plotted point of impact to the previously determined target location (fig. 81). All shifts are measured from the burst location to the target, perpendicular and parallel to the C₁-target line.
- (3) The plotter determines subsequent corrections on succeeding rounds and this information is furnished to the firing unit until the announced shift is less than 100 meters in deflection and range. The final shift is followed by the command FIRE FOR EFFECT.
- (4) The sound platoon ranges on the fire for effect and furnishes a report of its accuracy to the firing unit. If a heavy concentration of fire in the target area causes difficulty in interpreting the sound ranging record, additional single rounds following the fire for effect may be requested. If the accuracy of fire is judged to be satisfactory, the command END OF MISSION is given; if the accuracy is determined to be unsatisfactory, an additional shift is given and the command REPEAT FIRE FOR EFFECT is given.

116. Surveillance of Fire

The sound platoon may be called on to provide surveillance of fire on a target which has or has not been located by sound ranging. Normally, since a heavy concentration of fire produces a complicated record, the sound platoon requests that one or more single rounds be fired at the center of impact to check the accuracy

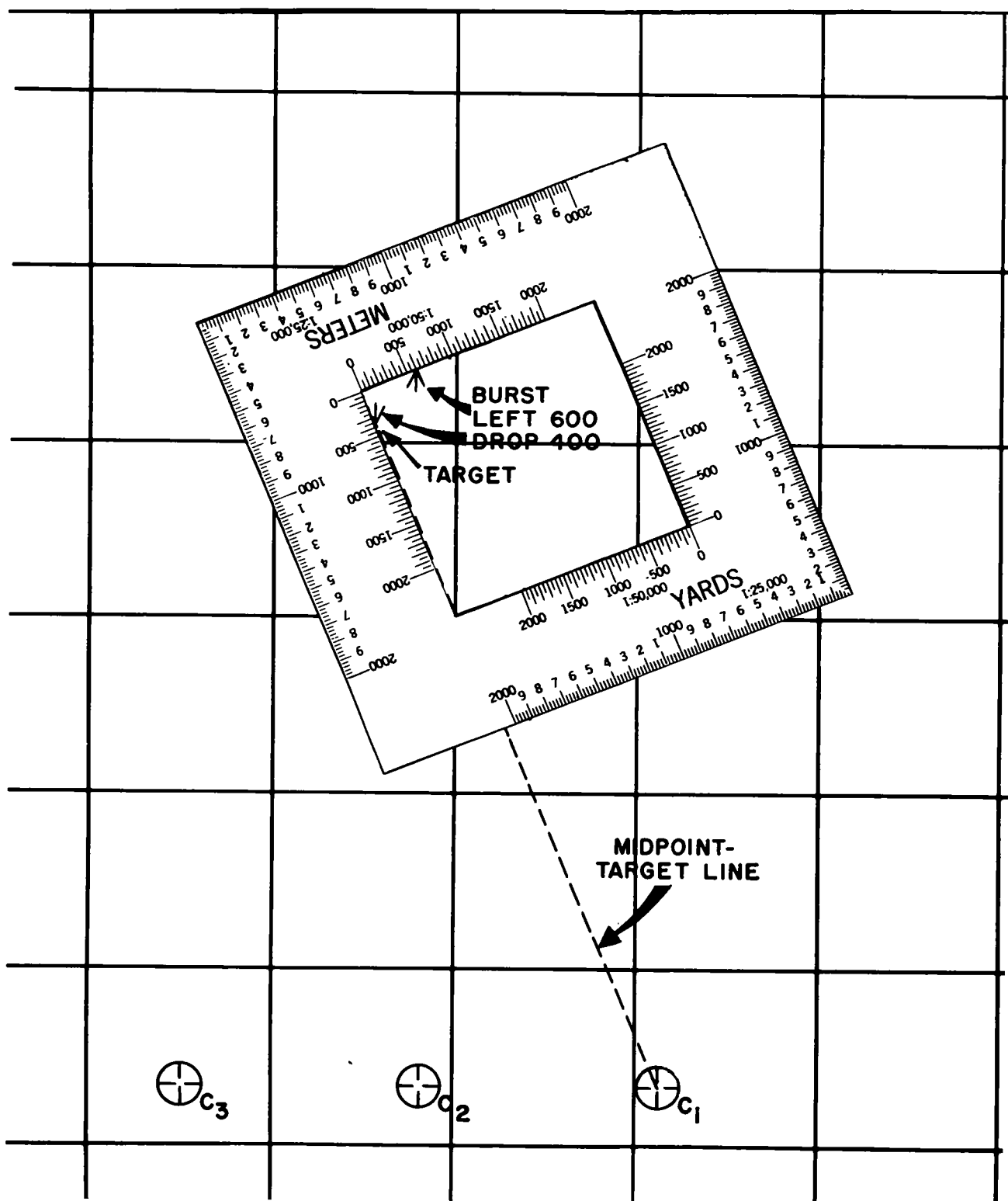


Figure 81. Determining a shift by using the sound-on-sound method.

of the concentration after it has been fired. The rounds under surveillance are plotted, corrections are applied, and their locations are determined in the usual manner.

117. Transfer of Fire

If surprise fire is desired on the target, an auxiliary point may be selected on which to register by means of a center-of-impact registration. The point is selected by agreement between the sound platoon and the firing unit. The point selected should be about 500 meters to the flank of the target and in terrain similar to that in the vicinity of the target. A transfer of fire is then made from the auxiliary point to the target. (See FM 6-40 for details on transfer of fire.) The location of both the target and the auxiliary point is determined in the normal manner, either with corrections or without corrections as in the sound-on-sound procedure.

118. Center-of-Impact Registration

Owing to the inability of the sound platoon to provide height data and the inherent inaccuracies in sound ranging methods which, under some weather conditions, do not meet the requirements of a precision registration, registration of artillery by sound ranging should be attempted only if all visual means fail. When center-of-impact registration data for a firing unit is requested, the following procedure is followed:

a. The firing unit fires six rounds, with the base piece, at the same deflection and elevation. The sound platoon determines and plots the mean time intervals of the six bursts and determines the final corrected location in the same manner as for any sound ranging location.

b. The sound platoon determines the mean center of impact and reports it to the firing unit.

PART TWO

ARTILLERY FLASH RANGING

CHAPTER 17

GENERAL

119. Definition

Flash ranging is the procedure employed to locate points in the target area by visual observation and intersection from two or more observation posts. Two types of installations are employed by the flash platoon—the flash short base and the flash long base.

120. Missions of the Flash Platoon

The flash platoon performs five principal missions. These missions are—

a. Provide Target Acquisition to Corps Artillery. Hostile artillery is located by the flash platoon by flash ranging methods.

b. Registration of Friendly Artillery. Center-of-impact and high-burst registration data are furnished by friendly units by the flash platoon.

c. Adjustment of Friendly Artillery. Flash platoon personnel also adjust artillery fire when called on to do so.

d. Collection of Battlefield Information. The collection of battlefield information is an important function of all flash observers. Flash observers provide the greater part of the battlefield information reported by the field artillery target acquisition battalion.

e. Comparative Calibration. Flash platoon personnel furnish comparative fall-of-shot data to friendly artillery units when called on to do so.

f. Verification of Nuclear Burst Location. The location of nuclear rounds delivered by friendly forces may be verified by the flash platoon. The flash platoon also reports the height of the cloud at stabilization.

121. Organization of the Flash Platoon

One flash platoon is organic to each target

acquisition battery of the field artillery target acquisition battalion. The flash platoon (fig. 82) means four observation posts and furnishes the necessary flash command post (CP) personnel for continuous operation. The platoon commander, a lieutenant, is the battery flash ranging officer.

122. Tactical Employment of Flash Platoons

The mission of flash ranging can be accomplished in both mobile and static types of warfare.

a. Mobile Warfare. In mobile warfare, flash platoons are employed aggressively in order to provide sustained coverage. Reconnaissance must be continuous so that displacements can be made when required by the tactical situation. The initial installation will usually be a short base with expansion to a long base whenever possible. Adjustment on active targets will be the rule, rather than the reporting of a corrected target location. Control will be decentralized as required by the speed of movement.

b. Static Warfare. The flash ranging installation employed in static warfare will usually be a long base. The initial installation may or may not be a short base. A short base, if used initially, will be expanded to a long base as quickly as the situation permits. Coordinates of locations of targets will be reported to higher echelons. Fewer adjustments on active targets will be conducted in static warfare than in mobile warfare. Control will be centralized. Alternate positions will always be prepared in order that displacement may be accomplished, whenever required, with continuous coverage.

123. Principal Duties of Key Personnel

The principal duties of key personnel of the flash platoon are listed in *a* through *h* below.

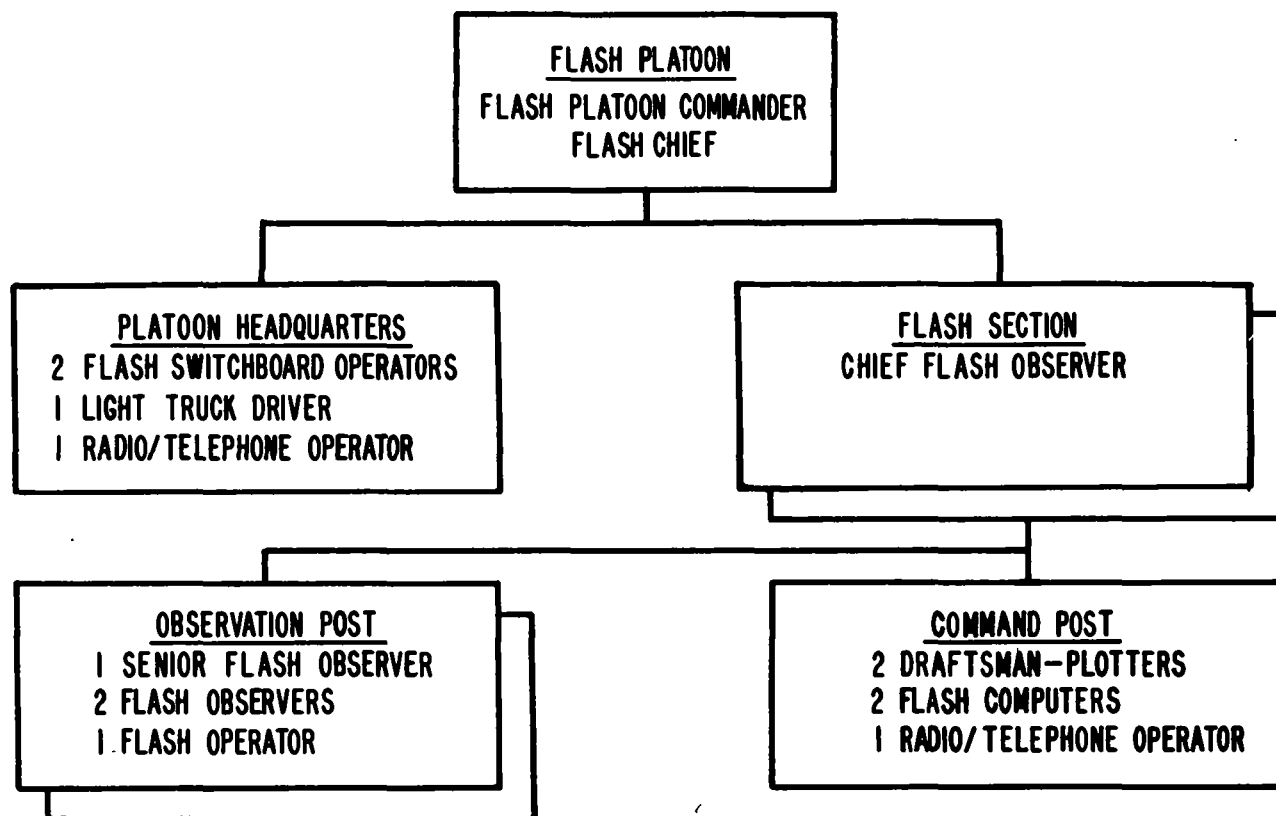


Figure 82. Organization of the flash platoon.

a. Platoon Commander. The platoon commander—

- (1) Directs and supervises all operations and training of the flash platoon.
- (2) Advises the battery commander on all matters pertaining to flash ranging.
- (3) Maintains liaison with adjacent units to insure that local security is maintained for the entire installation.
- (4) Performs aggressive reconnaissance, prepares future plans, and recommends displacements when they become necessary.
- (5) Informs the survey officer of the location of each OP.

b. Flash Chief. The flash chief—

- (1) Assists the platoon commander in supervising all operations and training of the flash platoon.
- (2) Insures that all personnel are informed of the tactical situation.
- (3) Supervises the preparation of an overlay of the operations area.

(4) Coordinates survey methods in the installation of the short base.

(5) Informs the chief flash observer of intervisibility and accessibility of intervening terrain.

(6) Verifies plotting and computations.

(7) Evaluates flash reports and inspects records.

(8) Trains members of the platoon in individual duties.

(9) Supervises the testing and preventive maintenance of all equipment of the flash platoon.

(10) Inspects, tests, and spot checks equipment to insure proper operating condition.

(11) Coordinates the resupply and servicing of the flash OP's to provide for their continuous operation.

(12) Enforces security discipline to provide maximum security of all installations of the flash platoon.

c. Flash Switchboard Operator. The flash switchboard operator—

- (1) Serves as switchboard operator and recorder for the flash platoon.
- (2) Installs and tests the flash ranging switchboard.
- (3) Relays orientation data from the plotting team to the OP's.
- (4) Coordinates reports from the observers and relays necessary information to the plotting team.
- (5) Relays target data from the plotting team to the observers.
- (6) Enforces communication discipline.
- (7) Reports target locations and battlefield information to higher headquarters.

d. Flash computer. The flash computer—

- (1) During installation of the flash short base, computes base length from survey data. During operation of the flash short base, determines distance from OP 1 to the target and height of target by use of the military slide rule.
- (2) During installation of the flash long base, computes orienting data for the observation posts. During operation of the flash long base, determines height of targets by use of the military slide rule and determines data for three-point resection and graphical intersection problems. Computes vertical looking angles for high-burst registration.

e. Draftsman-Plotter. The draftsman-plotter—

- (1) Polar plots targets, using a range-deflection protractor, in operations involving the short base.
- (2) Operates the flash ranging plotting board as required. Plots the OP's in their proper positions on the board, after assigning appropriate numbers to the grid lines on the board.
- (3) Assists and supervises the setting of azimuths on the plotting board and

performs all necessary plotting to determine target locations and orienting data for observers.

- (4) Determines data to be sent to firing units during adjustment.

f. Chief Flash Observer. The chief flash observer—

- (1) Supervises the operation and training of the flash observers and the control of two OP teams.
- (2) Insures that the flash OP's are properly located and correctly oriented.
- (3) Informs the flash observers of the tactical situation.
- (4) Checks, calibrates, and adjusts all observing instruments.
- (5) Assists the flash chief in the resupply and servicing of the flash OP's.

g. Senior Flash Observer. The senior flash observer—

- (1) Supervises the installation and operation of a flash OP.
- (2) Verifies instrument orientation of the flash OP.
- (3) Supervises the proper construction and camouflage of the flash OP.
- (4) Requests, from the flash chief, the necessary rations and supplies for the flash OP.

h. Flash Observer (Operator). The flash observer (operator)—

- (1) Supervises or assists, as required, in the operation of a flash OP.
- (2) Sets up the observing instrument and verifies its orientation.
- (3) Measures and verifies the angles and distances involved in the initial installation of the flash OP.
- (4) Insures that the zone being observed is the correct one.
- (5) Insures that reports and records are properly made and kept.

CHAPTER 18

LONG BASE FLASH RANGING

Section I. GENERAL

124. General Description

a. Technique of Target Location. The flash long base locating techniques consists of locating a target or point in the target area by graphical intersection on a plotting board. Since targets are located graphically, a minimum of three rays forming an angle of intersection of at least 500 mils is required to provide an accurately defined point.

b. Observation Posts. A flash long base (fig. 83) must be composed of a minimum of three OP's; however, four OP's are preferred. OP's are numbered from right to left, facing the target area. As a general rule, the distance between the flank OP's must be such that the intersection angle at any target will be 500 mils or more. The base will occupy a front of approximately 6,000 meters, and provide coverage over a front of 10,000 meters. Each OP is equipped with a mil-measuring instrument, which is oriented with the zero line pointing in the direction of grid north. Each OP is manned by four men—a senior flash observer, two flash observers, and a flash operator.

c. The Command Post. At the CP, the flash chief supervises the work of all personnel of the platoon. The CP contains two major items of equipment, the switchboard and the plotting board. The personnel necessary to operate the CP include a switchboard operator and a plotting team composed of two draftsmen-plotters, one acting as an armsetter, and a computer.

d. Survey. Survey is considered complete when each OP is located to an accuracy of 1:1,000 (fifth order).

e. Communications. Radio is initially used for communication between OP's and between OP's and the CP. Cable from each OP to the CP is installed as soon as possible, and the FM radios at the OP's and CP are then used as alternate means of communication.

125. Considerations Governing the Employment of the Long Base

Four primary considerations govern the employment of the flash long base, and each must be analyzed before the decision to employ a long base can be made. The four considerations are time available, terrain, survey, and communications.

a. Time Available. Under favorable conditions, from 4 to 6 hours are required to complete the installation of a flash long base. During an offensive operation the target area might move beyond the zone of observation before a long base could be completely installed.

b. Terrain. A long-base can best be installed on high ground overlooking open or rolling terrain where many OP sites are available which provide observation into the same target area. Wide sectors of observation common to three or more OP's are required since at least three observers must report a target before a graphic intersection can be considered valid and accurate.

c. Survey. The survey requirements for the flash long base are more easily fulfilled if survey control points are available in the vicinity of the base and visible control points are plentiful. If survey control must be carried for long distances, survey requirements are more difficult to meet. Consideration must be given to the availability of the target acquisition battery survey platoon to perform the long base survey.

d. Communications. Since radio is the initial, and later the supplementary, means of communication, the suitability of the base for radio operation must be considered. The time required to complete the wire net depends on the terrain and the distances over which the cable must be laid.

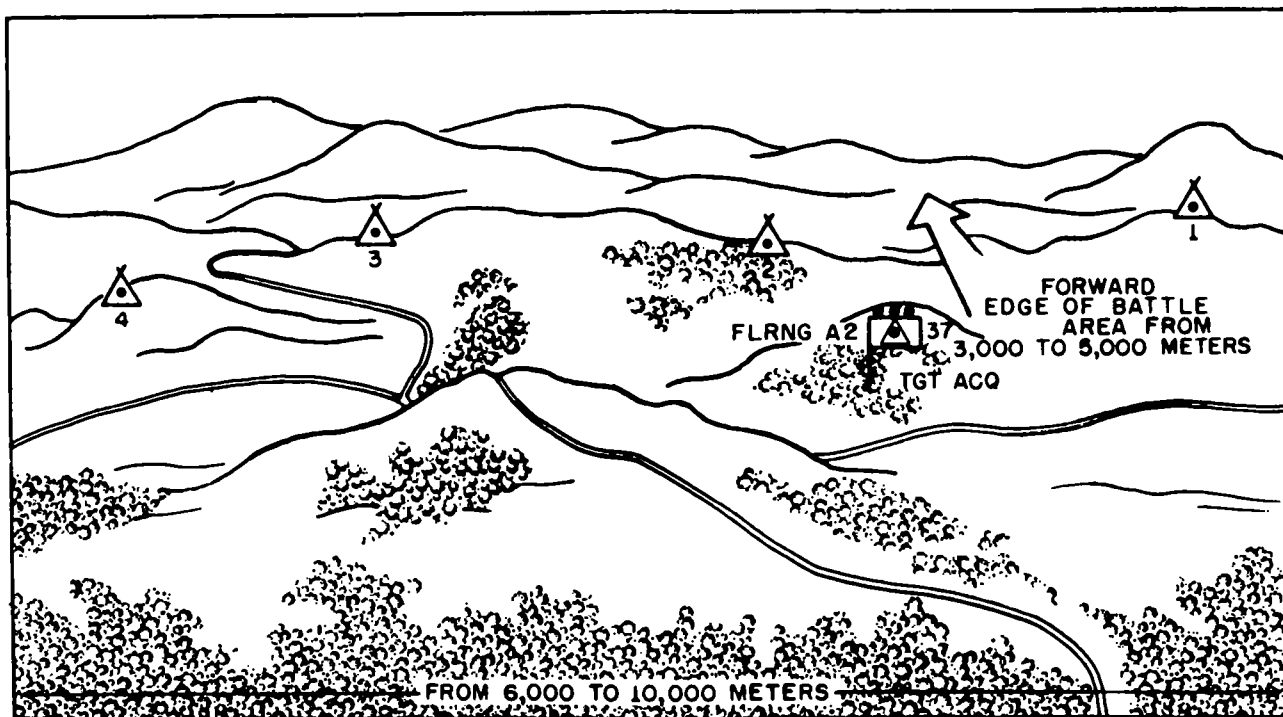


Figure 83. The flash long base.

126. Capabilities and Limitations

a. Capabilities. Any target which can be visually observed from three or more flash OP's can be accurately located by a flash long base. When a target is directly in the line of sight, it can be located with an accuracy of from 0 to 50 meters. The flash long base can range in depth up to the limit of visibility and in width from 6,000 to 10,000 meters.

b. Limitations. The long base is subject to the same limitations imposed on any ground visual system. These limitations include—

(1) Poor visibility due to—

- (a) Fog, heavy rain, or haze.
- (b) Smoke, either friendly or enemy, in

the target area or in the area of the OP.

- (c) Flat terrain which does not afford high ground for observation.
- (d) Hilly terrain which affords deep flash defilade for enemy artillery and concealment for his troops.
- (e) Densely wooded areas or jungles which afford a maximum of cover and concealment for enemy troops and installations.
- (f) Use of flash reducing propellants by the enemy artillery.
- (2) Multiple firing by the enemy which makes it extremely difficult for all observers to sight on the same target.

Section II. RECONNAISSANCE, SELECTION, AND OCCUPATION OF POSITION

127. General

a. Before the flash platoon can effectively accomplish its assigned mission, it must occupy sound tactical positions. These positions must always be reconnoitered prior to occupation. The type and the amount of reconnaissance

conducted prior to occupation will depend on the time available. Both map reconnaissance and ground reconnaissance are performed whenever time permits.

b. Reconnaissance is started as soon as orders for employment of the unit have been received.

In many cases, the map reconnaissance can be completed prior to the receipt of orders, particularly when units have been operating in a sector for a length of time and are able to plan for the occupation of future positions.

c. When the time allotted to reconnaissance is limited, the reconnaissance plan must be so organized that reconnaissance can be accomplished as completely as possible in the time available. Map reconnaissance can be made at any time, but ground reconnaissance is most effective during daylight hours. Reconnaissance parties should be kept as small as possible. Survey and communication operations should begin as soon as possible.

128. Map Reconnaissance and Selection of Positions

a. *General.* The flash platoon commander usually makes a map reconnaissance for two bases forward (or to the rear) of the base currently in operation. When information is available on zones of action and the axis of advance, map reconnaissance is limited only by the availability of suitable maps.

b. *Maps.* The scale of maps used in reconnaissance for a flash ranging installation is usually 1:50,000 with relief shown by contour lines.

c. *Suitability of Terrain.* The type of terrain (hilly, wooded, etc.) may be determined readily from a map. More detailed inspection will indicate whether the area affords a sufficient number of high points and suitable fields of observation for a long base installation.

d. *Observation Posts.* Tentative or approximate locations for OP's are selected from the map. For a detailed map reconnaissance, lines of sight may be checked by constructing a profile. Distance between the flank OP's should be at least one-half the required maximum distance of observation. The base should be so oriented that the perpendicular bisector of the line connecting flank OP's will pass through the center of the target area.

e. *Flash Ranging Command Post.* After the OP locations have been selected on the map, the location of the CP is selected. This installation should be located to the rear of and near the center of the base. The CP should be in a well-concealed location near the route to higher

headquarters. The suitability of the location for radio communication should be considered in selecting a location for the flash CP.

f. *Routes of Approach.* The flash platoon commander should make a careful map study of the road net in order to select routes which provide maximum concealment. Alternate routes should be selected to insure ease of movement around areas subjected to enemy fire and around destroyed bridges, etc.

g. *Alternate Positions.* It is important that alternate OP and CP locations be selected from the map. This step will save much time in ground reconnaissance. Alternate positions should possess the same characteristics as primary positions.

h. *Cable Routes.* Tentative cable routes should be selected to aid in estimating the approximate amount of cable needed to install the base. Cableheads should be selected in a concealed location in the vicinity of each OP to prevent the activity of the wire crews from disclosing the location of the OP.

i. *Survey Control Points.* When trig lists (lists of coordinates of survey control points) are available, as many of the listed points as possible should be plotted on the map. The points which are visible from the selected OP's are determined (by profiling if necessary). At this time it can be determined whether the flash platoon can survey any of the selected OP's by graphical resection, graphical intersection, or short traverse without waiting for the survey platoon to bring in survey control. When trig lists are not available, points which can be used as reference points should be plotted on the map.

129. Ground Reconnaissance and Selection of Positions

a. *General.* The ground reconnaissance, prior to a displacement of the flash platoon, is begun as soon as the situation permits. Ground reconnaissance may be started from an occupied position or from a rendezvous area. The purpose of the ground reconnaissance is to confirm or improve the locations selected during the map reconnaissance.

b. *Orienting the Ground Reconnaissance Party.* Before leaving the rendezvous area or

old position, the flash platoon commander should inform the men in the party of the key points along the route to be traveled. He should also specify the area where any accompanying communication and survey vehicles are to be left and an area where all personnel are to meet after accomplishing their assigned tasks.

c. Restriction of Movement. To avoid compromising the OP locations, there should be little movement in the vicinity of the OP's. All personnel should make maximum use of concealment. Vehicles should *always* be left well to the rear of the area being reconnoitered.

d. Principles. In order to efficiently and effectively conduct the ground reconnaissance, the flash platoon commander should observe the following principles:

- (1) Keep the reconnaissance party as small as possible.
- (2) Assign specific tasks to each individual.
- (3) Orient every member of the party on the routes to be used and when and where to rendezvous.
- (4) Restrict movement in the new area.
- (5) Obtain all available information on the current situation before starting the reconnaissance and any information that may be available from troops in the area being reconnoitered.

130. Composition of the Reconnaissance Party

a. The reconnaissance party should be composed of the minimum essential personnel. Higher headquarters will often direct that a reconnaissance party be made of certain vehicles, equipment and personnel. No one directive or list can possibly outline a party which is suitable for all situations. The personnel, equipment, and vehicles listed below are representative of a typical reconnaissance party.

- (1) A typical reconnaissance party and loading plan is as follows:

- (a) Vehicle No. 1
 - 1/4-ton truck
 - Flash platoon commander
 - Chief surveyor
 - Chief flash observer
 - Wire team chief

- (b) Vehicle No. 2
 - 1/4-ton truck
 - Recon-survey officer
 - Flash chief
 - Chief flash observer
 - Wire team chief

- (2) *Equipment.* Items of equipment of a typical reconnaissance party include—

- (a) Maps.
- (b) Field glasses.
- (c) M2 compass.
- (d) Orienting stakes.
- (e) Position markers.

b. The survey parties and one wire crew, if available, should be held in covered positions some distance to the rear so that they can start their operations as soon as the installation areas are selected.

131. Duties of the Reconnaissance Party

Each individual in the reconnaissance party should be directed to perform a specified part of the reconnaissance. A typical breakdown of duties is as follows:

a. Flash Platoon Commander. The flash platoon commander—

- (1) Takes charge of the reconnaissance.
- (2) Coordinates the efforts of the party, orients members of the party, assigns duties, and checks critical points personally.
- (3) Approves selected positions and cable route plans.
- (4) Selects a platoon release point for an initial occupation.

b. Survey Officer. The survey officer—

- (1) Obtains information on the location of OP's and reference points and assigns part of the reconnaissance to the survey chief of party.
- (2) Issues necessary orders to implement the survey plan.

c. Chief Flash Observers. The chief flash observers—

- (1) Obtain information on tentative OP locations from the flash platoon commander. (This information may be obtained during the map reconnaissance.)

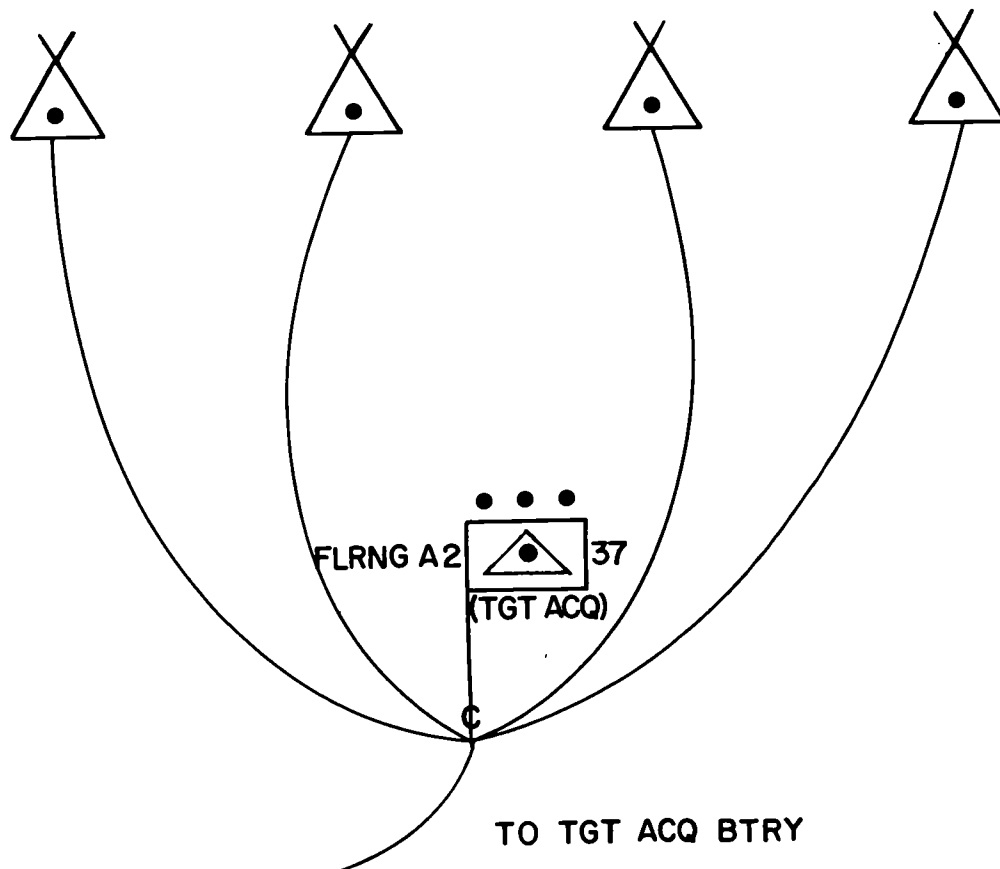


Figure 84. A typical flash platoon wire net.

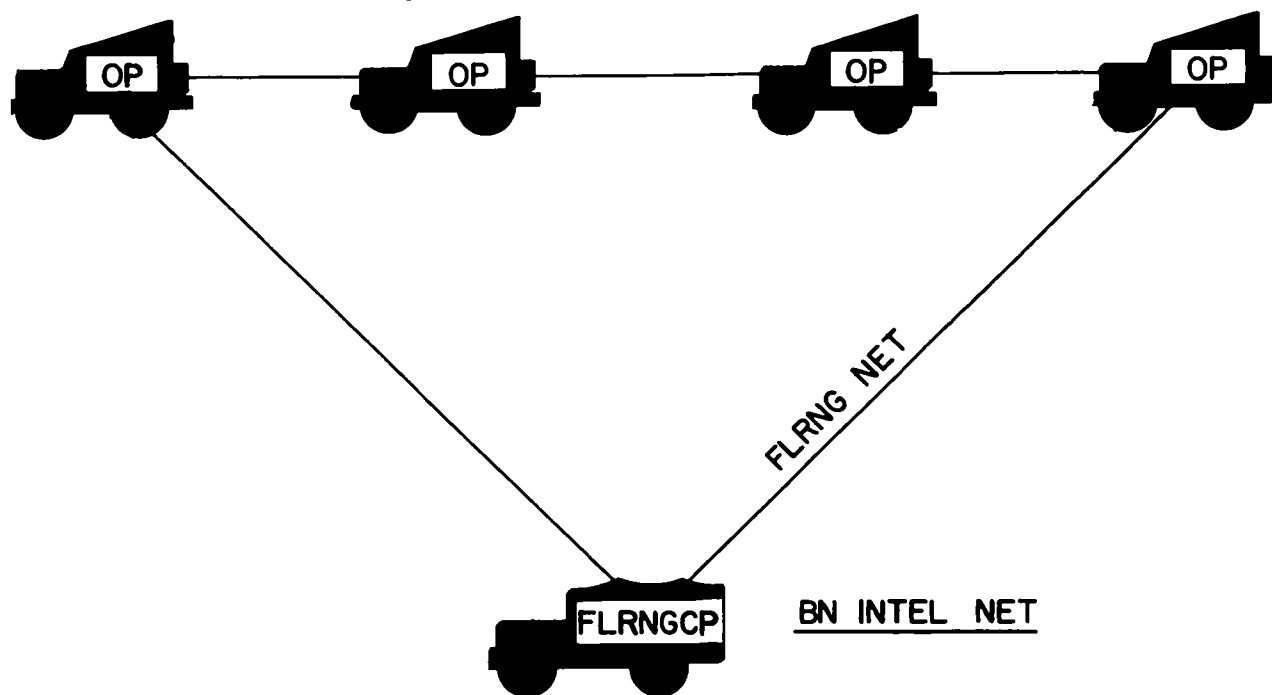


Figure 85. A typical flash platoon radio net.

- (2) Make a physical reconnaissance of the OP areas and routes of approach, position orienting stakes, and check visibility and fields of observation.
- (3) Identify control points and reference points in the target area.

d. Wire Team Chief. The wire team chief—

- (1) Obtains information on the location of the flash CP and the OP's from the flash platoon commander and/or the chief flash observer.
- (2) Reconnoiters cable routes, selects local cableheads in the vicinity of each OP, determines amount of cable required, and plans for the installation of cable to alternate positions and from the flash CP to the battery switchboard.

e. Chief of Survey Party. The chief of survey party—

- (1) Makes reconnaissance as directed by the survey officer.
- (2) Assists the survey officer in formulating the survey plan and performing necessary survey.

132. Occupation of Position

a. Daylight Occupation. As soon as possible after the reconnaissance and selection of positions have been completed, the platoon will proceed in a march column to the platoon release point. Personnel from the reconnaissance party, acting as guides, will meet the OP and CP teams at the release point and lead them directly to their positions. Movement and noise in the vicinity of the positions must be kept to a minimum to avoid disclosing the position locations.

b. Displacement. Displacement from an operating base to new positions differs from an initial occupation in that the platoon normally

does not displace as a unit. During displacement, the OP teams move individually as the situation dictates, and operation remains continuous throughout the move.

c. Night Occupation. Night occupation may be desirable when a daylight occupation would be difficult or impossible to conceal or when time is limited. When a night occupation is to be made, the number of guides must be increased and provision must be made for marking the route to the flash CP and the OP's. Two stakes will have been emplaced during daylight hours for use in orienting each observing instrument at night. One stake should be a few meters from the instrument position and in line with the instrument position and with the second stake, which should be at least 100 meters from the instrument position. The near stake is used to assist the OP team in finding the distant orienting stake. Noise should be restricted even more at night than during daytime to avoid revealing the position. Light discipline must be strictly enforced.

133. Communications

a. Cable. Immediately on completion of the reconnaissance and selection of positions, the wire crews will start installing the platoon wire net (fig. 84). Normally, the wire crews will begin at the CP and lay cable toward each OP. The OP team, in order to minimize movement in the vicinity of the OP, will lay cable from the OP to a local cablehead.

b. Radio. Since radio is initially used as the means of communication, the platoon radio net (fig. 85) will be used for operation until the wire net is established. After the wire net is in operation, radio becomes an alternate means of communication. Radios will be ready to operate at all times in case wire communications fail.

Section III. SURVEY

134. Requirements

a. The coordinates and height of the OP and the azimuth and vertical angle to a visible azimuth mark must be determined at each OP.

b. All survey for flash ranging installations

performed by the battery survey platoon must be performed to an accuracy of 1:1,000. Survey performed by the flash platoon may be performed to lesser accuracy (1:500). Azimuths to the azimuth marks must be accurate to within 1 mil.

135. Survey Platoon Survey

The survey platoon of the target acquisition battery will normally carry survey control to a point in the vicinity of each OP (FM 6-2). The survey personnel will begin the flash base survey as soon as practicable after the reconnaissance and selection of the OP's are complete.

136. Flash Platoon Survey

a. General. Flash platoon personnel will normally carry survey control from a survey control point established by the target acquisition battery survey platoon in the vicinity of each OP to the OP installation. If the survey platoon is not available, flash platoon personnel will be required to establish survey control for the OP by using existing control points.

b. Short Traverse. The flash platoon may determine the grid coordinates of the OP's by a short traverse from either the survey control points established by the survey platoon or existing survey control points. The flash platoon personnel will traverse from the survey control to the OP's by using the observing instrument and a tape. (For a discussion of traverse procedures, see FM 6-2.)

c. Graphical Three-Point Resection. When the coordinates of three suitable points are known and all three points are visible from the OP, graphical three-point resection may be employed in determining the location of an OP by use of the plotting board. Detailed procedures for the solution of graphical three-point resection will be found in paragraph 143.

d. Graphical Intersection. When it is possible for an OP of unknown location to be reciprocally laid (oriented) from another OP which has already been located and oriented, graphical intersection may be used to determine the location of the OP if, in addition, an observer at the OP of unknown location is able to sight to another point of known location. Detailed procedures for the solution of graphical intersection will be found in paragraph 144.

e. Inspection. If accurate maps are available but survey control is not immediately available, the OP's of the flash platoon may initially be located by map inspection. *Care must be taken to insure that all instruments are oriented parallel; this may be accomplished in one of the following ways:*

- (1) A line on the ground which is clearly defined on the map is determined. The azimuth of this line is scaled from the map. An instrument is set up on one end of this line and, by using the scaled azimuth, direction is carried by a directional traverse to each OP (FM 6-2).
- (2) One OP may be oriented by using a magnetic needle. Directional control may then be carried to the other OP's by a directional traverse.
- (3) All observing instruments can be oriented parallel by simultaneous observation of a celestial body by all observers. (For a discussion of simultaneous observation, see FM 6-2.)

Section IV. OPERATING PROCEDURES

137. Observation Post Procedures

a. Observer Team. The observer team consists of a minimum of four men—one senior flash observer and three flash observers (operators). OP's must be manned continuously; therefore, each man must be able to perform any of the duties required at the OP. Additional men are desirable for extended operation. Two men will be on duty at all times, one acting as the observer and the other as assistant observer. The observer operates the observing instrument, reads and reports horizontal and ver-

tical angles to targets, and executes all instructions issued from the CP. The observer searches the target area in a deliberate pattern while the assistant observer studies the target area as a whole. The assistant observer maintains a constant watch for activity, provides for local security, and maintains all records and sketches.

b. Outpost Unit. By depressing the switch on the outpost unit, the observer can signal the switchboard the instant a target is sighted and, at the same time, can communicate by telephone with the flash switchboard by using a single

cable line. (See fig. 32. The outgoing cable is connected to the flash switchboard rather than to the sound ranging CP.)

c. Orientation. Observation of the target area should begin as soon as possible after the observer team reaches the OP position, even though survey and communication may not have been completed. The observer must familiarize himself with the target area as quickly as possible. On occupying the OP, the observer first orients the observing instruments so that the scales read zero when the telescope is pointed toward grid north. This is done by setting the azimuth to the azimuth mark on the scales of the instrument and sighting the telescope on the azimuth mark. The azimuth to the azimuth mark may be computed (FM 6-2), measured by compass (TM 9-575), read from a map, determined by reciprocal laying (para. 144); or determined by astronomic observation (para. 136).

d. Use of Maps. If available, maps and aerial photographs of the area under observation will provide detailed information such as location of roads, hills, survey control marks, etc. Using a map, the observer can determine the approximate azimuths and approximate distances from the OP to points in the target area.

e. Use of Panoramic Sketches. Although maps and aerial photographs are valuable sources of information to the observer, they do not show exactly what can or cannot be seen from the OP. For this purpose, a panoramic sketch is drawn by the observer (FM 21-35).

f. Observing Procedure. The observers at the various OP's of the flash base should identify reference points in the target area in correlation with the observers at the other OP's. This will enable them to point out targets to each other by referring to mutually identified points. The azimuth and estimated distance to these reference points should be entered on each OP team's panoramic sketch and map. So that the assigned zone of observation will be covered, a definite pattern of observation must be used. The observing instrument should be moved slowly while the observer studies the terrain. The observer should turn his instrument through angles of 100 mils (fig. 86), from one side of the target area to the other, raising or lowering the elevation by 100-mil intervals as either side of the target area is reached. This pattern should be followed until the entire zone of observation is covered. The pattern will depend on the nature of the terrain and the zone of observation. The assistant observer on duty

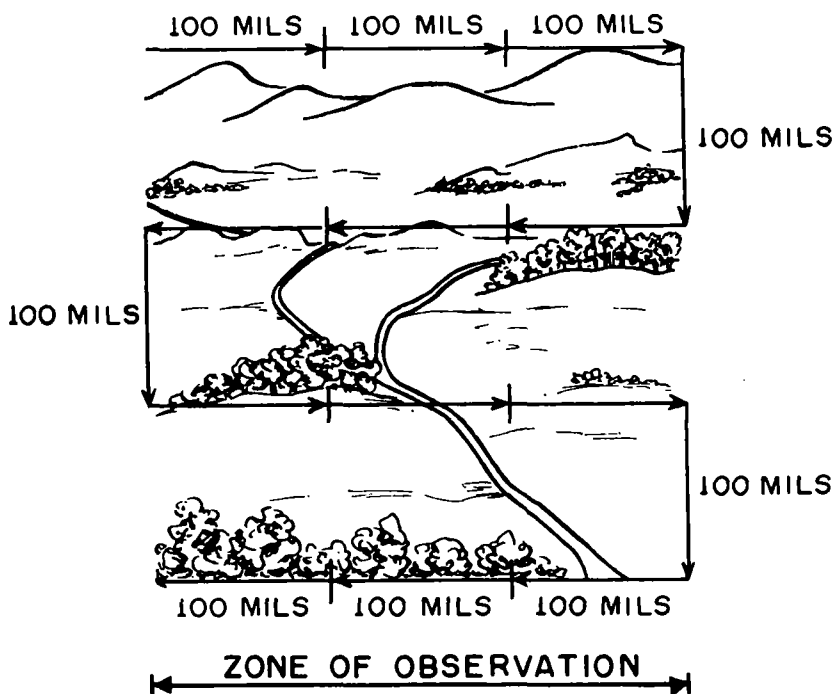


Figure 86. Observation pattern.

flash is seen until the time the sound of the weapon firing is heard. By multiplying the number of seconds recorded by the distance that sound travels per second (roughly 350 meters per second), the observer arrives at an approximate distance, in meters, from the OP to the target.

- (2) *Depression ranging.* Distance to the target can be determined from a single OP, if an accurate map on which the OP can be located is available, by determining the direction and vertical angle to the target. A ray is drawn on the map from the OP along the measured azimuth to the target. A profile section (FM 21-26) is drawn along this ray. The intersection of this line with the ground will furnish a close approximation of the distance to the target.

138. Flash Command Post Procedures

a. *Personnel.* The CP is manned by the flash platoon commander, the flash chief, the switchboard operator, and the plotting team. The plotting team consists of three men—two draftsmen-plotters (one utilized as an armsetter) and a computer. The plotting team may be supplemented by a second computer, although the flash chief or the flash platoon commander may perform the necessary check computations.

- (1) *Switchboard operator.* The switchboard operator is responsible for communication discipline, assists in observer control, records and announces the reports from the observers to the plotting team, transmits data for orientation and approximate azimuths to the observers, and maintains the appropriate records including DA Form 6-6, Record of Sound, Flash, and Radar Locations (fig. 88).
- (2) *Armsetter.* The armsetter sets and reads the mil scale of the plotting board.
- (3) *Draftsman-plotter.* The draftsman-plotter performs all drafting, reads coordinates and distances, assesses accuracy of location, and manipulates the plotting board.
- (4) *Computer.* The computer determines the heights of targets and performs any other necessary computations.

b. *Flash Ranging Set AN/GTC-1.* The flash platoon is highly dependent on good communications for proper functioning and requires a dependable, efficient communication system linking the observers at the OP's with the flash CP. This communication system must meet the special problems which may be encountered in target acquisition by flash ranging. The flash ranging set AN/GTC-1 includes all components (except cable and batteries) required to

RECORD OF SOUND, FLASH, AND RADAR LOCATIONS												
PERIOD COVERED:		FROM				TO				SHEET NUMBER	NUMBER OF SHEETS	
		TIME	DATE			TIME	DATE					
L	M	N	O	P	Q	R	S	T	U			
FROM (FILE NO)	GRID REFERENCE AND HEIGHT E AND H	ACCURACY H METERS NO PLOTS	THREAT BY LOCATION TIMES ACTIVE (FROM-TO)	NATURE OF TARGET	REMARKS (AREA SHELLED, ETC)	TIME REPORTED TO ARTY CP	MISSION FIRED BY	NUMBER OF ROUNDS	COORD NO			
1	52372350	412 50 3	3 OPs 0922-0930	LIGHT GUN FIRING		0927 0937						
2	51722300	396 25 1	4 OPs 0940	4 GUN BATTERY	GRID REFERENCE 51302860	0944						

Figure 88. Typical entries on the Record of Sound, Flash, and Radar Locations, DA Form 6-6.

operate the flash ranging telephone system. The components, operation, and maintenance of this set are described in TM 11-5516. The largest and most important item in the set is the switchboard SB-4. This switchboard will accommodate local telephone lines from six OP's and one trunkline from higher headquarters. It is equipped with toggle switches instead of the conventional jacks and plugs. These switches allow the switchboard operator free use of his hands so that he can act as recorder for the flash platoon. The switchboard is equipped with line lamps which act as signaling devices when incoming calls are received. A night alarm buzzer allows the operator to relax during periods of little or no activity and still maintain close supervision over the switchboard. Link keys enable the operator to route as many as three separate conversations through the board at one time. This allows observers at two or more OP's to work together on specific target areas and be able to communicate over separate circuits.

c. Communication Checks. As each cable line is installed, the switchboard operator checks the switchboard circuits by the tests prescribed in TM 11-5516. Each observer is called until all lines have been checked for proper functioning

of outpost unit circuits, ringing circuits, and talking circuits. Thereafter, OP lines are periodically checked to insure proper functioning.

d. Orienting Observers.

(1) *Procedure.* When the switchboard circuits have been checked, the switchboard operator furnishes orienting data to the observers. Using the procedure described in (2) below, the switchboard operator alerts the senior flash observer at each OP who has signified that he is ready for orientation and announces the data to each in turn. The data announced include—designation of the azimuth mark, azimuth to the azimuth mark, and vertical angle to the azimuth mark (fig. 89). The observer reads back all data announced. Following the announcement of data, the switchboard operator requests all observers to report when orientation has been accomplished and the observers are ready to observe. After each observer announces READY, the switchboard operator so informs the plotting team and the FATAB operations section.

(2) *Example.*

Switchboard operator: REPORT WHEN READY FOR ORIENTATION.

Observers: OP 1 (2) (3) (4), READY.

Switchboard operator: OP 1 (2) (3) (4), ORIENTATION FOLLOWS: OP 1, AZIMUTH MARK LEFT EDGE OF TOWER ON LITTLE HILL, AZIMUTH 5103.2, VERTICAL ANGLE PLUS 10.2; OP 2-----.

Observers: OP 1 (2) (3) (4), ORIENTATION FOLLOWS: AZIMUTH MARK LEFT EDGE OF TOWER ON LITTLE HILL, AZIMUTH 5103.2. VERTICAL ANGLE PLUS 10.2. (OP (2) (3) (4)).

Switchboard operator: REPORT WHEN READY TO OBSERVE.

Observers: OP 1 (2) (3) (4), READY TO OBSERVE.

Switchboard operator: OP 1 (2) (3) (4), READY TO OBSERVE.

(To the plotting team and FATAB operations section.)

e. Recording Observation Post Orienting Data. The switchboard operator enters the following information on DA Form 6-3, Orienting Data for Flash Ranging Observation Posts (fig. 89).

(1) The coordinates and height of each OP.

(2) A brief description of the azimuth mark.

(3) The azimuth and vertical angle (VA) to the azimuth mark.

f. Flash Ranging Locations.

(1) *Procedure, all observers on target.*

ORIENTING DATA FOR FLASH-RANGING OBSERVATION POSTS (FM 6-150)						
DATE		TIME		AREA		
		0800		BALD RIDGE, FT SILL, OKLA.		
OP NR	COORDINATES AND HEIGHT			AZIMUTH MARK		
	E	N	H	DESCRIPTION OF OBJECT	AZIMUTH	VERT Δ
1	63946.1	38960.4	393	TRIG MRK JOCELYN	6023.8	-2.4
2	62366.4	38863.3	393	TRIG MRK JOCELYN	91.2	-1.8
3	61337.3	39207.6	396	TRIG MRK JOCELYN	342.6	-2.3
4	60307.2	39265.0	398	TRIG MRK JOCELYN	558.6	-2.4
5						
6						

DA FORM 6-3 REPLACES DA AGO FORM 6-3, 1 FEB 54, WHICH IS OBSOLETE

☆ GPO : 1955 O - 354910

Figure 89. Orienting Data for Flash Observation Posts, DA Form 6-3.

Each observer, on sighting a target, closes his outpost unit switch. This causes the observer's line lamp to glow on the switchboard, alerting the switchboard operator. When several line lamps glow simultaneously, the switchboard operator assuming that all the observers saw the same target, requires each observer to report in turn. The observers render a standard, four-element report. The four elements are the azimuth from the OP to the target, the accuracy of the azimuth, the vertical angle from the OP to the target, and a brief description of the target. The azimuth accuracy is designated by ALFA, BRAVO, or CHARLIE. ALFA denotes an accurate reading; BRAVO, an azimuth error of 2 mils or less; CHARLIE, an azimuth error greater than 2 mils. The switchboard operator records these data on the Flash Ranging Record, DA Form 6-3a, and repeats the data back to the observers, loudly enough that the arm-setter can hear the data received. If all observers have identified the target but some have reported BRAVO or CHARLIE readings, the target can be plotted. As long as the target is active, the observers should attempt to obtain

ALFA readings to improve the accuracy of the target location.

- (2) *Procedure, two or more observers on target.* An observer who does not see the target reports OP (number), lost. If only two or three observers have identified the target, the plotting team will determine observing (looking) azimuths for the other observers from the plotting board. The switchboard operator transmits these azimuths to the appropriate observers.
- (3) *Procedure, one observer on target.* If only one observer signals, the switchboard operator receives the standard observer report (1) above from that observer and, in addition, an estimation of the distance from the observer to the target. The plotting team after polar plotting the target from the one OP then determines observing (looking) azimuths for the observers at the other OP's, and the switchboard operator transmits these azimuths to those observers.
- (4) *Plotting targets.* Azimuths reported from each OP are plotted as described in paragraph 141. The flash platoon commander or the flash chief inspects the observer reports and the target plot and determines whether the plot

is usable as a target location. If the plot is usable, the draftsman-plotter reads and announces to the switchboard operator the grid reference of the target and assesses the accuracy of the plot (para. 147). The draftsman-plotter also reads and announces to the computer the distance to the target from two observation posts designated by the flash platoon commander or the flash chief. The computer determines and announces to the switchboard operator the height of the target (*h* below).

- (5) *The flash location report.* Targets reported by the flash platoon will normally be reported by grid reference and height. If the flash platoon and the firing units are not on a common

grid, the flash CP personnel may designate the location of the target by a shift from a known point or by polar coordinates by using the plotting board. By using the shift from a known point, the azimuth from any suitable OP can be used as the OT (observer-target) line (FM 6-40). The flash ranging location report will also contain a brief description of the target, an estimation of the accuracy of the plot, and the time at which the target was observed.

- (6) *Successive plots.* Successive plots of the same target are processed as in (4) above, and the mean grid reference and height of the mean center of polygons is determined and reported, including the number of usable plots.

(7) *Example.*

(OP 2 observer presses outpost switch.)

Switchboard operator: OP 2, REPORT.

OP 2 observer: OP 2, 3050 CHARLIE, MINUS 3.0, LIGHT GUN FIRING.

Switchboard operator: OP 2, 3050 CHARLIE, MINUS 3.0, LIGHT GUN FIRING: OP 1, OP 3. OP 4, DID YOU OBSERVE LIGHT GUN FIRING?

OP 1 observer: OP 1, LOST.

OP 3 observer: OP 3, LOST.

OP 4 observer: OP 4, LOST.

Switchboard operator: OP 2, REPORT ESTIMATED DISTANCE TO TARGET.

OP 2 observer: OP 2, ESTIMATED DISTANCE, 4,500 METERS.

Switchboard operator: OP 1, OP 3, OP 4, ESTIMATED DISTANCE FROM OP 2 TO TARGET 4,500 METERS.

Armsetter: AZIMUTH: OP 1, 2750.0; OP 3, 3310.0; OP 4, 3595.0.

Switchboard operator: OP 1, OP 3, OP 4, LOOK FOR LIGHT GUN FIRING, OP 1, AZIMUTH 2750.0; OP 3, AZIMUTH 3310.0; OP 4, AZIMUTH 3595.0.

OP 1 observer: OP 1, 2750.0.

OP 3 observer: OP 3, 3310.0.

OP 4 observer: OP 4, 3595.0.

(Observers at all OP's press outpost switches.)

Switchboard operator: OP 1, REPORT.

OP 1 observer: OP 1, 2752.0 CHARLIE, MINUS 4.0, LIGHT GUN FIRING.

Switchboard operator: OP 1, 2752.0 CHARLIE, MINUS 4.0, LIGHT GUN FIRING: OP 2, REPORT.

OP 2 observer: OP 2, 3045.0 BRAVO, MINUS 3.0.

Switchboard operator: OP 2, 3045.0 BRAVO, MINUS 3.0; OP 3, REPORT.

OP 3 observer: OP 3, 3310.0 CHARLIE, MINUS 2.4.

Switchboard operator: OP 3, 3310.0 CHARLIE, MINUS 2.4; OP 4, REPORT.
OP 4 observer: OP 4, 3600.0 BRAVO, MINUS 5.0.
Switchboard operator: OP 4, 3600.0 BRAVO, MINUS 5.0.
(Observers at all OP's press outpost switches.)
Switchboard operator: OP 1, REPORT.
OP 1 observer: OP 1, 2751.8 ALFA, MINUS 4.2, LIGHT GUN FIRING.
Switchboard operator: OP 1, 2751.8 ALFA, MINUS 4.2, LIGHT GUN FIRING: OP 2, REPORT.
OP 2 observer: OP 2, 3045.2 ALFA, MINUS 2.8.
Switchboard operator: OP 2, 3045.2 ALFA, MINUS 2.8; OP 3, REPORT.
OP 3 observer: OP 3, 3311.6 ALFA, MINUS 3.0.
Switchboard operator: OP 3, 3311.6 ALFA, MINUS 3.0; OP 4, REPORT.
OP 4 observer: OP 4, 3599.4 ALFA, MINUS 4.4.
Switchboard operator: OP 4, 3599.4 ALFA, MINUS 4.4.
Draftsman-plotter: GRID REFERENCE 5237523520; ACCURACY 20 METERS; DISTANCE OP 1 TO TARGET 5200, DISTANCE OP 2 TO TARGET 4700.
Computer: HEIGHT 412.
Switchboard operator: LIMA, ALFA FLASH ONE; MIKE, 5237523520; 412; 20, ONE; (To higher head-quarters.) NOVEMBER, 4OP's; OSCAR, 0850 to 0900; PAPA, LIGHT GUN; QUEBEC, 524286.

g. The Flash Ranging Record. Entries on the Flash Ranging Record, DA Form 6-3a, are made by the switchboard operator as indicated in figure 90. The computation of target height on the flash ranging record is discussed in *h* below. The switchboard operator enters all target information on the flash ranging record. Entries in the following spaces of the form require further explanation:

- (1) *Azimuth.* The azimuth, together with the letter (A, B, or C) indicating the accuracy of the azimuth, and the vertical angle as reported by each OP.
- (2) *Grid reference.* Recorded as accurate as the draftsmen-plotter can scale from the plotting board.
- (3) *Height.* Height computation is discussed in paragraph *h*.
- (4) *File number and time reported.* The assigned file number for that day and the time the location was reported to higher headquarters.
- (5) *Accuracy.* Estimated accuracy of the location.
- (6) *Time active.* The time the weapon was first observed by the OP's.

- (7) *Nature of target.* Description of target in sufficient detail to allow the fire direction officer (FDO) to select proper ammunition and fuze for target. Weapons are grouped as light, medium, heavy, or very heavy.
- (8) *Remarks.* The area shelled, if known.
- (9) *Conc number.* The concentration number assigned by the unit firing on the target. The concentration number may be used for future reference.

h. Computation of Height. The computer computes the target height on the flash ranging record by using the data reported by two observers (*f* (1) above). The height is computed in meters, depending on the vertical control of the maps being used by the firing units in that area. The computer solves for the two target heights by entering the data shown in (1) through (10) below. If the two heights so computed do not agree to within 1 meter, the target height is computed from data reported by a third observer.

- (1) *Sum.* All usable vertical angles reported are added.
- (2) *Mean.* The average vertical angle is

FLASH-RANGING RECORD (FM 6-122)															DATE		
ROUND	OP 1			OP 2			OP 3			OP 4			OP 5			GRID REFERENCE	
	AZIMUTH	ACC	VERT $\pm$	AZIMUTH	ACC	VERT $\pm$	AZIMUTH	ACC	VERT $\pm$	AZIMUTH	ACC	VERT $\pm$	AZIMUTH	ACC	VERT $\pm$	E	N
1	2751.8	A	-4.2	3045.2	A	-2.8	3311.6	A	-3.0	3599.4	A	-4.4				52375	23520
2																	
3																	
4																	
5																	
6																	
7																	
8																	
9																	
10																	
SUM																	
MEAN																	
OT DISTANCE	5200			4700													
HEIGHT OF OP	432.0			424.0													
TARGET HEIGHT ABOVE/BELOW OP $\pm$	21.4			12.9													
ALGEBRAIC SUM	410.6			411.1													
CURV. AND REFR. CORR. $\pm$	1.8			1.5												HEIGHT 412 YDS (M)	
HEIGHT	412.4			412.6												SUM H 825.0	MEAN H 412.5
FILE NO. 1	ACCURACY (Meters)	TIME ACTIVE		NATURE OF TARGET (To include caliber)				REMARKS (Area shelled, control)				CONC NO.					
TIME REPORTED 0709	20	FROM 0850	TO 0900	LIGHT GUN				524286									

DA FORM 6-3a

PREVIOUS EDITIONS OF THIS FORM ARE OBSOLETE.

Figure 90. Typical entries on the Flash Ranging Record, DA Form 6-3a.

obtained by dividing each sum by the number of usable plots.

- (3) *OT distance.* The distance from the OP to the target is entered.
- (4) *Height of OP.* The surveyed height of each OP is entered.
- (5) *Target height above/below OP.* The computer solves for the difference in height between the OP and the target by using the sine-tangent function scale of the military slide rule (TM 6-240).
- (6) *Algebraic sum.* The computer adds to the height of OP (or subtracts from the height of OP) the target height above/below the OP.
- (7) *Curvature and refraction corrections.* Heights of locations at distances

greater than 2,500 meters must be corrected for errors caused by the curvature of the surface of the earth and the refraction of light rays. The computer obtains these corrections by entering the curvature and refraction table on the back of the flash ranging record with the distance to the nearest 100 meters; for example, at a distance of 6,300 meters, the C&R is 2.7.

- (8) *Height.* The curvature and refraction correction is always added to the algebraic sum to determine the height of the target.
- (9) *Sum H.* The heights determined from the two OP's are added.
- (10) *Mean H.* Sum H is divided by 2 to obtain the mean height of the target.

Section V. PLOTTING

139. General

In order for a flash platoon to efficiently locate points in the target area from a flash long base, rapid and accurate plotting of grid azimuths is required. The flash ranging plotting board, if available, is used for this purpose. If a plotting board is not available, a grid sheet, map, or aerial photograph, together with a range-deflection protractor, can be used to plot grid azimuths.

140. The Flash Ranging Plotting Board

a. Description. The flash ranging plotting board (fig. 94) consists of a rotating table with a 1:25,000-meter grid engraved on its top surface (plotting disk or surface), a drafting machine with a graduated straightedge (plotting arm) attached, and the necessary supporting base and legs. The straightedge is graduated in meters and is used to measure distances. An azimuth scale of 6,400 mils, graduated every 10 mils and numbered every 100 mils, is attached around the circumference of the top surface of the table. A vernier scale, attached to a bracket, is provided for making azimuth settings to the nearest 0.5 mil.

A slow-motion and braking mechanism is housed within the bracket to permit accurate setting of the announced azimuth and to keep

the table from rotating during plotting. The surface of the table is such that pencil marks can be easily erased.

Caution: To avoid scratching the plotting surface, do not use a pencil of greater than 3H hardness.

b. Personnel. Two men operate the plotting board—the armsetter and the draftsman-plotter. The armsetter operates the slow-motion and braking mechanism to set off azimuths; the draftsman-plotter operates the drafting machine to plot the azimuths as set off on the azimuth scale and to scale the coordinates or the distances required.

c. Orientation. To orient the plotting board, the armsetter releases the brake by pressing the brake lever (fig. 91) and rotates the table until the graduated edge of the plotting arm is parallel to a north-south gridline on the plotting disk and the zero on the azimuth scale is next to the zero on the vernier scale (fig. 94). The armsetter then clamps the table by releasing the brake lever and rotates the slow-motion knob (fig. 91) until the zeros are in coincidence. The board is oriented when the azimuth vernier is set at zero and the plotting arm is parallel to a north-south gridline. If this procedure does not result in orientation, the vernier

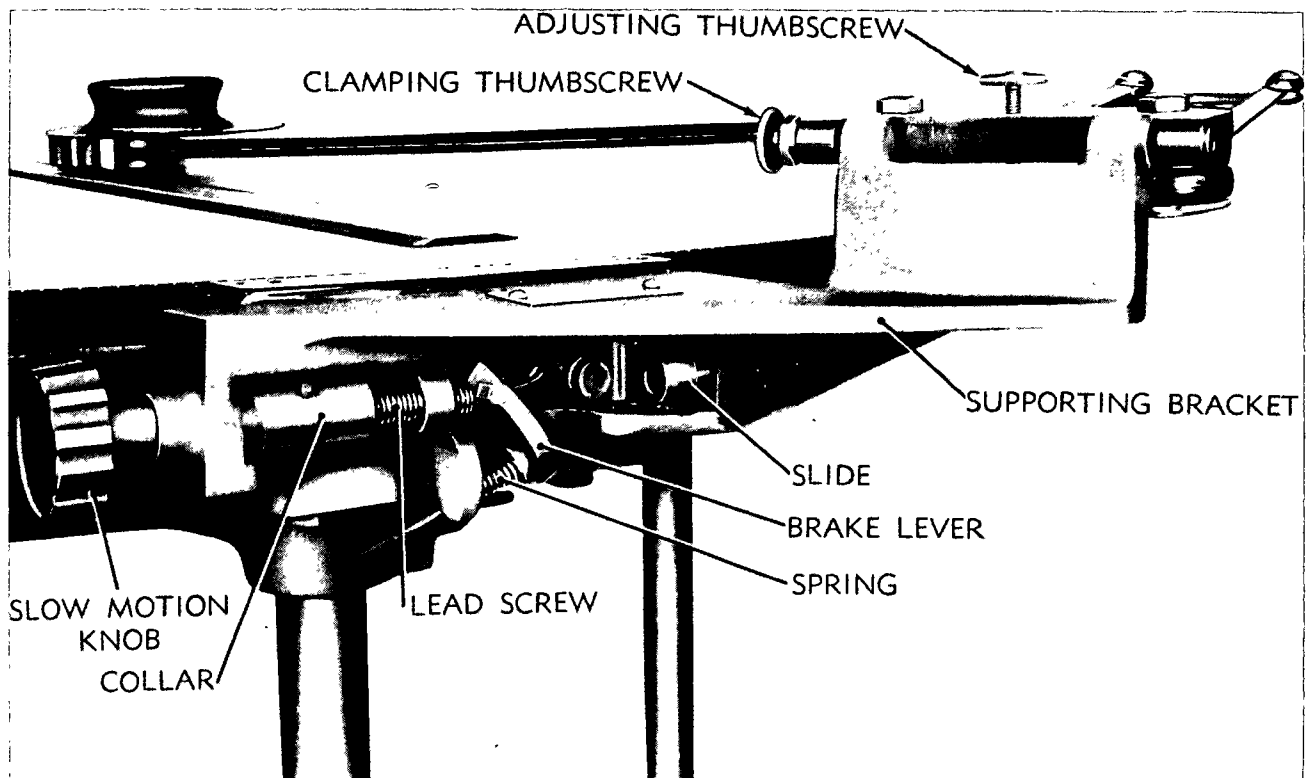


Figure 91. Slow-motion and braking mechanism of the plotting board.

scale or plotting disk must be adjusted as described in *d* below.

d. Setting Azimuths.

- (1) In operating the slow-motion scale for vernier readings, the brake lever must always be released (the normal position due to the action of the spring), thus engaging the brake. However, when the armsetter or draftsman-plotter rotates the table rapidly to set the approximate azimuth, the armsetter must press in the lever and hold it firmly. The vernier scale is adjusted by rotating the table until the zero on the azimuth scale is roughly opposite the zero on the vernier scale. With the brake engaged, the slow-motion knob is rotated until a northing gridline coincides with the edge of the plotting arm. The screws which hold the vernier scale are loosened, and the vernier scale is moved until the zero on the vernier scale is exactly opposite the zero on the azimuth scale. The screws

are then tightened. If it is not possible to so position the scales, the plotting disk may be adjusted. The plotting disk is adjusted by loosening the six screws which secure the plotting disk to the tabletop, turning the plotting disk in the desired direction, and then tightening the screws. The vernier scale is then readjusted until it is set on zero. If the six screws cannot be loosened or if time does not permit orienting the board properly, the plotting arm is placed parallel to a gridline and the azimuth scale is set to an approximate zero reading. The vernier scale is read and the difference is carried as a constant correction.

- (2) When the azimuth is announced, the armsetter presses the brake lever and rotates the table until the zero graduation on the vernier scale is between the nearest 10-mil graduation and the next higher 10-mil graduation on the azimuth scale. The armsetter then re-

leases the brake lever and rotates the slowmotion knob until the numbered graduation on the vernier scale, corresponding to the last digit of the announced azimuth, coincides with the nearest graduation on the azimuth scale. The armsetter then announces SET.

- (3) As an example, assume that the announced azimuth is 2,204 mils. The azimuth scale is set so that the zero on the vernier scale is opposite the space between the 2,200 and 2,210 graduations (almost in the center since the last digit is 4). The brake lever is then released and the slowmotion knob is rotated until the 4 graduation on the vernier scale coincides with the nearest graduation on the azimuth scale (2,280). If the announced azimuth were 2,208, it would be necessary to rotate the knob until the 8 graduation on the vernier scale coincided with the 2,360 graduation on the azimuth scale. Readings can be set to the nearest 0.5 mil by using the intermediate readings on the vernier scale.

e. Plotting Azimuths. The armsetter sets off the desired azimuth (*d* above) and announces SET. The draftsman-plotter positions the plotting arm so that the edge of the straightedge passes through the plotted position of the OP from which the grid azimuth was measured, draws a ray from the OP towards the armsetter, and announces LINE.

f. Reading Azimuths. To read grid azimuths, the draftsman-plotter rotates the table, aligns the plotting arm on the OP and the point to which the azimuth is to be determined, and announces READ. The armsetter operates the slow-motion and braking mechanism (*c* above) as directed by the draftsman-plotter and reads the grid azimuth on the azimuth and vernier scales.

Note. The grid azimuth is measured from the OP to the target area.

141. Plotting Procedures, General

a. General. The plotting procedures in this manual are for use with the plotting board. However, the plotting procedures are essentially

the same when a grid sheet, map, or aerial photograph and a range-deflection protractor are used. For instructions on the use of the range-deflection protractor, see FM 6-40.

b. Numbering the Gridlines. The gridlines on the plotting surface must be assigned numbers which correspond to the grid system of the area in which the flash platoon is operating. These numbers may be assigned by determining, from a map, a grid reference for the center of the board or by noting the direction of ranging and comparing the grid coordinate of the OP's. In order to make maximum use of the plotting surface, it is necessary that the OP's be plotted as close to the edge of the board as possible. When it is known that only targets at short distances are to be located, the plotting board may be numbered on a scale of 1:12,500 to obtain greater accuracy.

142. Plotting the OP's

When surveyed coordinates (para. 135 and 136) of an OP are furnished or an OP is located by inspection. The location of the OP will be plotted by using the triangular boxwood scale. The location of an OP can also be plotted by graphical resection (para. 143) or graphical intersection (para. 144).

143. Graphical Three-Point Resection

a. General. Two factors must be considered in selecting the three known points for use in three point resection. First, the OP must not be located on or near a circle passing through the three known points, and second, the sum of the two horizontal angles measured by the observer must not be less than 500 mils nor more than 2,700 mils. These two factors must be considered during the map reconnaissance in order to determine which known points will give the best possible solution. The known points selected must be identified to the observer during the ground reconnaissance in order to insure positive identification. There are three possible cases to be considered in solving a three-point resection problem (fig. 92). In all three cases, points A, B, and C are the three known points and point P, the location of the OP, is the point to be located. Point I is not a point on the ground but is only a point on the circle that must be located in order to determine the azimuth from P to B.

b. Procedure for Case 1. In case 1 (1, fig. 92), point P falls inside the triangle formed by the three known points (A, B, and C). The procedure is as follows:

- (1) The draftsman-plotter plots known points A, B, and C on the plotting board.
- (2) The observer at point P turns angles P_1 and P_2 , closes the horizon (FM 6-2), and reports these angles to the flash CP.
- (3) The draftsman-plotter and armsetter measure the azimuth from A to C on the plotting board.
- (4) The computer determines angle CAI by subtracting angle P_2 from 3,200 mils ($3,200 - P_2$). (Angle CAI subtends the same arc as angle CPI.)
- (5) The azimuth from A to C, plus angle CAI, is equal to the azimuth from A to I.
- (6) The computer determines the azimuth from C to A (azimuth from A to C $\pm$ 3,200 mils).
- (7) The computer determines angle ACI by subtracting angle P_1 from 3,200 mils ($3,200 - P_1$). (Angle CAI subtends the same arc as angle CPI.)
- (8) The azimuth from C to A, minus angle ACI, is equal to the azimuth from C to I.
- (9) The draftsman-plotter and armsetter draw the azimuth rays from A to I and from C to I on the plotting board.
- (10) The intersection of these rays fixes point I.
- (11) The draftsman-plotter and armsetter draw line BI.
- (12) The draftsman-plotter and armsetter measure the azimuth from P to B (I to B).
- (13) The azimuth from P to B is sent to the observer as his orienting azimuth.
- (14) The azimuth from P to B, minus angle P_1 , is equal to the azimuth from P to A.
- (15) The azimuth from P to B, plus angle P_2 , is equal to the azimuth from P to C.
- (16) The draftsman-plotter and armsetter draw the azimuth rays from P to A

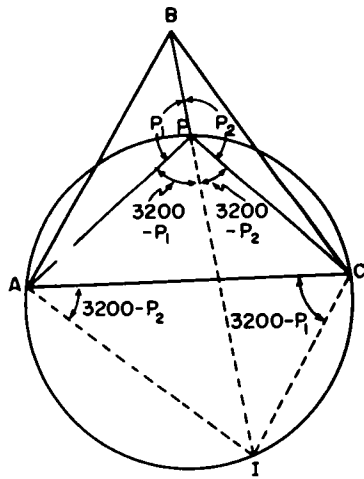
and from P to C through A and C, respectively.

- (17) The intersection of rays PA and PC with the ray from P to B fixes point P.

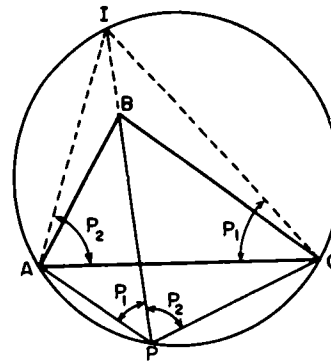
c. Procedure for Cases 2 and 3. In case 2 and 3 (2 and 3, fig. 92), point P falls outside the triangle formed by the three known points (A, B, and C). The procedure is as follows:

- (1) The draftsman-plotter plots known points A, B, and C on the plotting board.
- (2) The observer at P turns angles P_1 and P_2 and reports these angles to the flash CP.
- (3) The draftsman-plotter and armsetter measure the azimuth from A to C on the plotting board.
- (4) The azimuth from A to C, minus angle P_2 , is equal to the azimuth from A to I.
- (5) The computer determines the azimuth from C to A (azimuth from A to C $\pm$ 3,200 mils).
- (6) The azimuth from C to A, plus angle P_1 , is equal to the azimuth from C to I.
- (7) The draftsman-plotter and armsetter draw the azimuth rays from A to I and from C to I on the plotting board.
- (8) The intersection of these rays fixes point I.
- (9) The draftsman-plotter and armsetter draw line BI, extended.
- (10) The draftsman-plotter and armsetter measure the azimuth from P to B.
- (11) The azimuth from P to B is sent to the observer as his orienting azimuth on point B.
- (12) The azimuth from P to B, minus angle P_1 , is equal to the azimuth from P to A.
- (13) The azimuth from P to B, plus angle P_2 , is equal to the azimuth from P to C.
- (14) The draftsman-plotter and armsetter draw the azimuth rays from P to A and from P to C on the plotting board through A and C, respectively.
- (15) The intersection of rays PA and PC with the ray from P to B fixes point P.

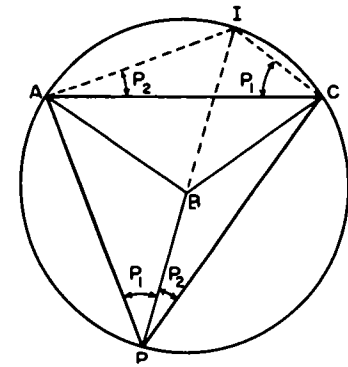
d. Height Determination for Resected OP. The following procedure is used to determine



① Procedure for case one



② Procedure for case two



③ Procedure for case three

Figure 92. Three-point resection.

the height of OP which has been located by resection:

- (1) The observer reads the vertical angles to two of the known points and reports them to the flash CP.
- (2) The draftsman-plotter measures the distances, on the plotting board, from the OP, the height of which is to be determined, to the known points to which the vertical angles were measured.
- (3) The computer, using the distance and vertical angle from the OP to one of the known points, computes the difference in height between the OP and the known point.
- (4) The difference in height is applied to
- (5) The computer determines the height of the OP by using the distance and vertical angle to the other known point as a check.
- (6) If the distance from the OP to the known point is more than 2,500 meters, the computer must apply the curvature and refraction correction. This correction is always negative when the height of a known point is used in determining the height of an OP.

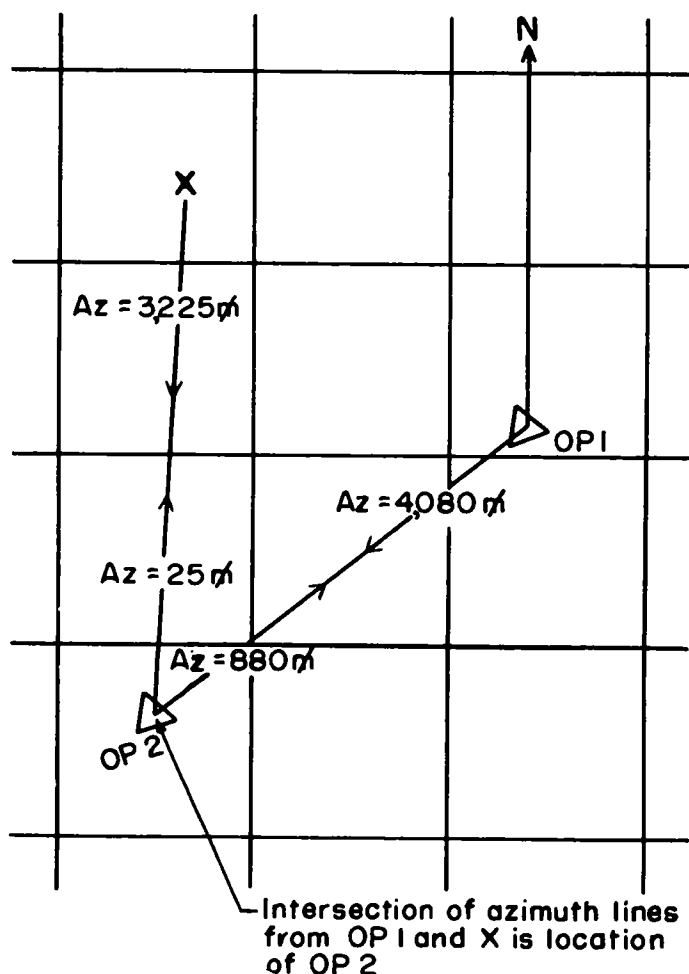


Figure 93. Graphical intersection.

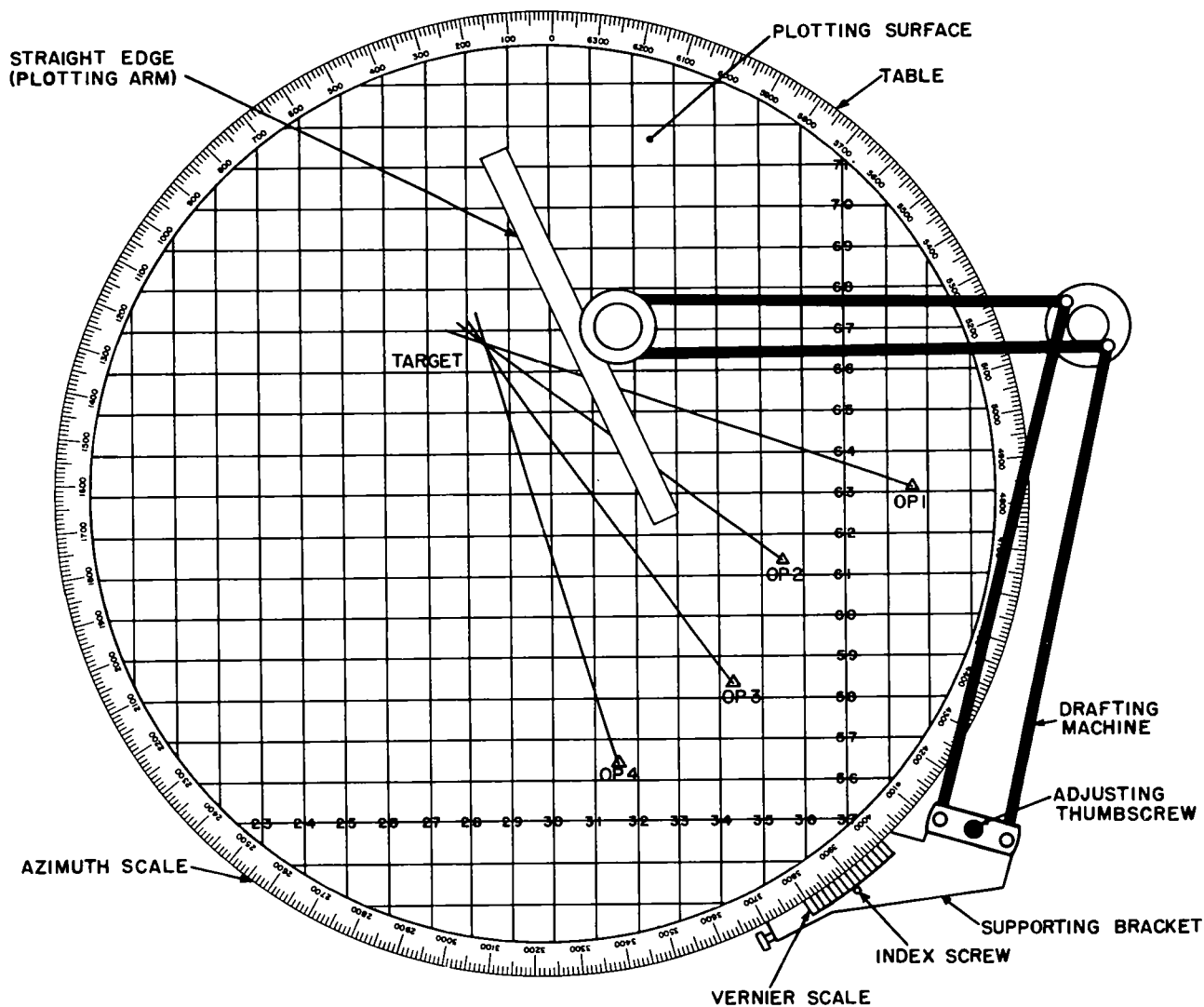


Figure 94. Flash ranging plotting board, with observation posts, rays, and target plotted.

144. Graphical Intersection

a. General. Graphical intersection (fig. 93) may be used to determine the location of an OP (OP 2) that is, first, intervisible with an OP (OP 1) that is already located and oriented and, second, that is so located that a third point (point X), located on a common grid with the already located OP, can be observed. It is desirable to use more than one known visible point to check the location of OP 2.

b. Procedure. The procedure is as follows:

- (1) The draftsman-plotter plots OP 1 and X on the gridded plotting board.

- (2) The observer at OP 1 sights his observing instrument on OP 2 and announces the observed azimuth to the observer at OP 2.
- (3) The observer at OP 2 sets the announced azimuth, $\pm 3,200$ mils, on his observing instrument with the telescope sighted on OP 1. OP 2 is now reciprocally oriented.
- (4) The observer at OP 2 sights his observing instrument on point X and announces the observed azimuth.
- (5) The draftsman-plotter draws azimuth rays on the plotting board from OP 1

and point X. The intersection of these rays fixes the location of OP 2.

145. Operation for Target Location

When the grid has been numbered and the OP's have been plotted, the plotting board is ready for azimuth readings from the OP's. As these azimuths are announced from each OP for a single burst or flash, they are plotted by the armsetter and draftsman-plotter (para. 140d and e). The intersection of the plotted azimuth rays marks the position of the target as observed (fig. 94). The easting and northing coordinates of this point can be determined by referring to the grid origin and scaling the distances to each axis by using a triangular box-wood scale. The horizontal distance from the target to any OP can be determined by using the scale on the plotting arm to scale the distance.

146. Polygon of Error

a. In many cases, all the rays of the flash ranging plot will not intersect at the time point;

that is, will not produce a *P* plot. Instead, the rays will intersect with one another to form a polygon of error that will vary in size, depending on the following factors:

- (1) Accuracy of the survey.
- (2) Accuracy of the orientation.
- (3) Accuracy of the reading by the observer.
- (4) Clarity, visibility, and size of the target.
- (5) Accuracy of the plotting.

b. A common sense evaluation of the polygon of error will produce a target location with the required accuracy. If all of the readings to the target are reported as ALFA (A) readings, the draftsman-plotter will plot the center of the polygon as the location of the target (1, and 2, fig. 95). If some of the readings are ALFA (A) readings and some are BRAVO (B) or CHARLIE (C) readings, the draftsman-plotter will place greater weight on the rays of ALFA readings (3, fig. 95). If the ray from the OP varies greatly from the others (4, fig. 95), the

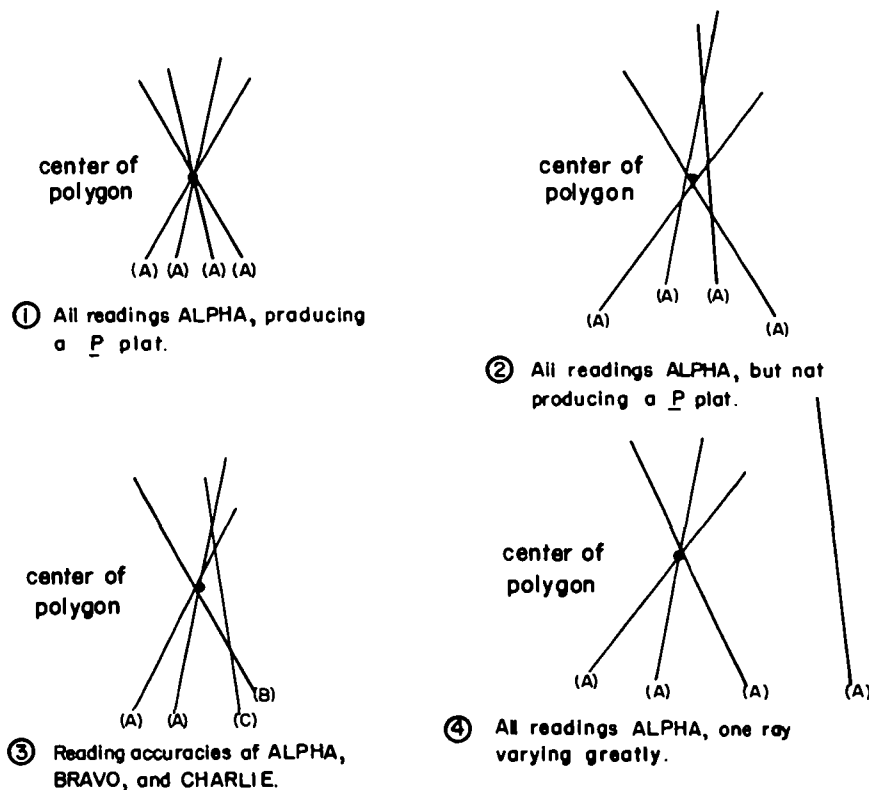


Figure 95. Evaluation of the polygon of error.

draftsman-plotter may assume that the observer at that OP is either sighting on the wrong tar-

get or has become unoriented and will give no weight to the ray from that OP.

Section VI. CONDUCT OF FIRE

147. Registration

General procedures for the conduct of high-burst (HB) and center-of-impact (CI) registrations will be found in FM 6-40. This paragraph discusses only those registration procedures which pertain to the flash platoon.

a. The fire direction officer (FDO) of the firing unit, with the assistance of the flash platoon commander, will decide on the type of registration (HB or CI) and the point for registration, depending on the zones of observation of the flash observers. The FDO will furnish the approximate grid reference and height of the expected registration point. In addition, the FDO will specify the number of rounds to be fired. The flash platoon commander may request that one or more orienting rounds be fired at his command to orient the observers and to insure positive identification of the initial rounds. Smoke shell may be requested to aid in the identification of the initial rounds. The flash platoon commander will specify the time interval between each round in the group for registration.

b. A rough plot of the registration point is made. The azimuth to this point from each OP is determined by rotating the plotting table until the plotting arm passes through the OP and the registration point and then reading the azimuth and vernier scales. These observing (looking) azimuths are then transmitted to the OP's, together with the approximate vertical angle to the burst. After these data are set on the observing instruments at the OP's, the observers announce **READY TO OBSERVE**.

c. The flash platoon commander commands **FIRE** for each of the initial orienting rounds. The firing unit announces, and the flash CP switchboard operator relays, **TIME OF FLIGHT** (so much), **ON THE WAY**, and **SPLASH** to the observers to assist them in identifying the burst.

d. As soon as the burst appears in the field of view of the observing instruments, the ob-

servers apply the reticle readings to the instrument scales to place the instrument crosshairs on the point of burst and thereafter leave the scales undisturbed. The observers then report the scale readings (clamping azimuth) to the CP. All subsequent readings are made right or left from the vertical hairline and plus or minus from the horizontal hairline of the reticle. The flash platoon commander requests subsequent orienting rounds until all the observers have determined clamping azimuths (ALFA readings). The switchboard operator records the clamping azimuth for each OP and DA Form 6-3a (fig. 96) and checks the clamping azimuths with the observers immediately on completion of the registration. If the azimuth is not the same as reported initially, the observations are unreliable and should be discarded. Particular care must be exercised in the reading of vertical angles. Bursts of the orienting rounds will be plotted at the flash CP to insure that all observers are observing the correct burst.

e. The flash platoon commander informs the FDO that the platoon is ready to observe the registration rounds. The instruments are not disturbed during the firing of the registration rounds. The firing unit announces **ON THE WAY** and **SPLASH** for each round it fires. The observers report reticle readings for each burst as follows:

- (1) *Observable bursts.* **RIGHT (LEFT)** (so much), **PLUS (MINUS)** (so much), **ALFA (BRAVO) (CHARLIE)**.
- (2) *Observable bursts outside the field of view of the instrument.* **DOUBTFUL**.
- (3) *Nonobservable bursts.* **LOST**.

f. The reticle readings from each OP are recorded by the computer at the CP. All readings are evaluated at the flash CP, and erratic readings are rejected. Additional rounds may be requested if the desired results are not obtained because of erratic readings or lost bursts. When satisfactory readings are obtained for six

FLASH-RANGING RECORD (FM 6-122)															DATE		
ROUND	OP 1			OP 2			OP 3			OP 4			OP 5			GRID REFERENCE	
	AZIMUTH	ACC	VERT	AZIMUTH	ACC	VERT	AZIMUTH	ACC	VERT	AZIMUTH	ACC	VERT	AZIMUTH	ACC	VERT	E	N
CLAMPING AZIMUTHS	6142.8	A	+14	6396.4	A	+12	141.0	A	+15	333.0	A	+13				68705	99825
2	R2	A	+2	R9	A	+2	L6	A	-2	L4	A	-2				68695	99790
3	R3	A	+4	R11	A	0	L4	A	-1	L1	A	+1				68700	99800
4	R2	A	+3	R13	A	+3	L4	A	0	R2	A	-4				68720	99795
5	R4	A	+4	R10	A	+4	L2	A	-1	L4	A	0				68700	99800
6	R2	A	+3	R11	A	+3	0	A	+2	R1	A	+2				68705	99790
SUM	R13		+16	R45		+12	L16		-2	L6		-3				412225	598800
MN $\frac{SUM}{5}$	R2.6		+3.2	R9		+2.4	L3.2		-0.4	L1.2		-0.6			$\frac{MN}{6}$	68704	99800
MEAN AZ	6145.4			0005.4			137.8			331.8			MEAN AZ PLOT =			68715	99790
10																	
SUM																	
MEAN			+17.2			+14.4			+14.6			+12.4					
OT DISTANCE	3350			3540			3450			3600							
HEIGHT OF OP	416.0			424.0													
TARGET HEIGHT ABOVE/ BELOW OP	+ 57.5			+ 50.0			+			+			+				
ALGEBRAIC SUM	473.5			474.0													
CURV. AND REFR. CORR. +	0.8			0.8			+			+			+			HEIGHT 474	
HEIGHT	474.3			474.8												SUM H 949.1	MEAN H 474.5
FILE NO.	ACCURACY (Meters)	TIME ACTIVE		NATURE OF TARGET (To include caliber)						REMARKS (Area shelled, control)						CONC NO.	
TIME REPORTED		FROM	TO	H. B. REGISTRATION													

DA FORM 6-3a
1 OCT 58

PREVIOUS EDITIONS OF THIS FORM ARE OBSOLETE.

Figure 96. Typical entries on DA Form 6-3a for a high-burst registration.

bursts, each round is plotted and the coordinates are recorded on DA Form 6-3a (fig. 96). Mean coordinates are determined for the six useable rounds. The computer determines the average deviation reported by the observer at each OP and the average azimuth and vertical angle from each OP to the burst. The average azimuth is plotted for each OP, and the plot produced is used as a check plot against the mean coordinates of each round plotted. The mean azimuth plot coordinates should agree to within 20 meters easting and 20 meters northing of the mean plot coordinates. The computer determines the height of the mean center of bursts (fig. 96).

g. When a center-of-impact registration is completed, the grid reference and height of the center of impact are reported to the firing unit. When a high-burst registration is completed, the grid reference and height of the center of burst are reported.

148. Adjustment of Fire

a. The facilities of the flash platoon may be employed to assist in the adjustment of area and precision fire on targets visible to the flash observers. Detailed instructions in the target grid method of adjusting fire are contained in FM 6-40. Observer readings to each burst are plotted at the flash platoon CP. Corrections are computed with respect to one of the observer-target (OT) lines (FM 6-40) and transmitted to the fire direction center (FDC) of the firing unit; range corrections are made to the nearest

10 meters. When the subsequent correction is 100 meters or less in deflection and range, the adjustment is considered complete and fire for effect is requested. Surveillance of fire will reveal the need for any further adjustment.

b. An individual flash observer is capable of adjusting fire as prescribed in FM 6-40 and may be called on to do so.

149. Transfer of Fire

If surprise fire is desired on an accurately located target, preliminary adjustment of fire on the target may be eliminated by performing a transfer of fire (FM 6-40). If the target is not within transfer limits of a registration point, the FDO, with the assistance of the flash platoon commander, will choose a suitable registration point from which the firing unit will be able to transfer fire to the target. Registration will be performed as described in paragraph 147.

150. Comparative Calibration

Comparative calibration is the comparison of the shooting strength of a given piece with that of another piece accepted as standard under the same firing condition. (FM 6-40). The shooting strength of each piece is determined by firing. The flash platoon providing comparative calibration data determines the center of impact for a group of six rounds or more for each piece. The procedure employed is identical with that employed for a center-of-impact registration (para. 147).

CHAPTER 19

SHORT BASE FLASH RANGING

Section I. GENERAL

151. General Description

The flash short base (fig. 97) consists of two OP's and a CP. The OP's are numbered from right to left, facing the target area, and are referred to as 01 and 02, respectively. The flash platoon is normally capable of operating two short bases simultaneously.

a. Base Length. The base length, the distance between the two OP's of the short base, must be determined by survey.

b. Technique of Target Location. Since the distance between the OP's is relatively short, graphical intersection as a means of target location is not satisfactory. In short base flash ranging, the technique of computed intersection is used, and targets are polar plotted on a plotting chart.

- (1) *Computed intersection.* Computed intersection involves the use of azimuths measured by the observers at the two OP's and the surveyed base length to compute the distance from 01 to the target.
- (2) *Polar plotting.* Targets are polar plotted from 01. The elements needed to establish a polar plot are a point of origin (01), a direction (the azimuth from 01 to the target), and a distance ((1) above).
- (3) *Plotting chart.* The point of origin, direction, and distance are plotted on a chart to locate the target. The plotting chart used will be either gridded or ungridded, depending on the availability of survey control.

152. Considerations Governing the Employment of the Short Base

The short base will be employed whenever an analysis of the four primary considerations—

time available, terrain, communications, and survey—shows that use of a long base would be impractical or impossible (para. 125). A short base will always be expanded to a long base when the situation permits.

a. Time available. A short base requires little time to install. In rapidly changing situations, a lack of time may preclude the use of a long base. Under favorable conditions, a short base can be in operation within 30 to 90 minutes after the reconnaissance has been completed.

b. Terrain. Since the short base consists of only two OP's separated by a relatively short distance, almost any type of terrain can accommodate a short base. The short base is particularly adaptable to rugged terrain where more than two of the OP's of a long base would not have a common sector of observation.

c. Communications. The communication system of a short base requires shorter communication links than a long base and is less complex and easier to install.

d. Survey. Short base survey, consisting initially of base length and azimuth determination and orientation of the observing instruments, is less time consuming and easier to perform than long base survey. The survey of a short base can be performed without previously existing control by the personnel of the flash platoon.

153. Capabilities and Limitations

a. Capabilities. The short base has the same basic capabilities as the long base (para. 126); in addition—

- (1) The short base is more readily subject to change than the long base.
- (2) Less time is required to install a short base than a long base.

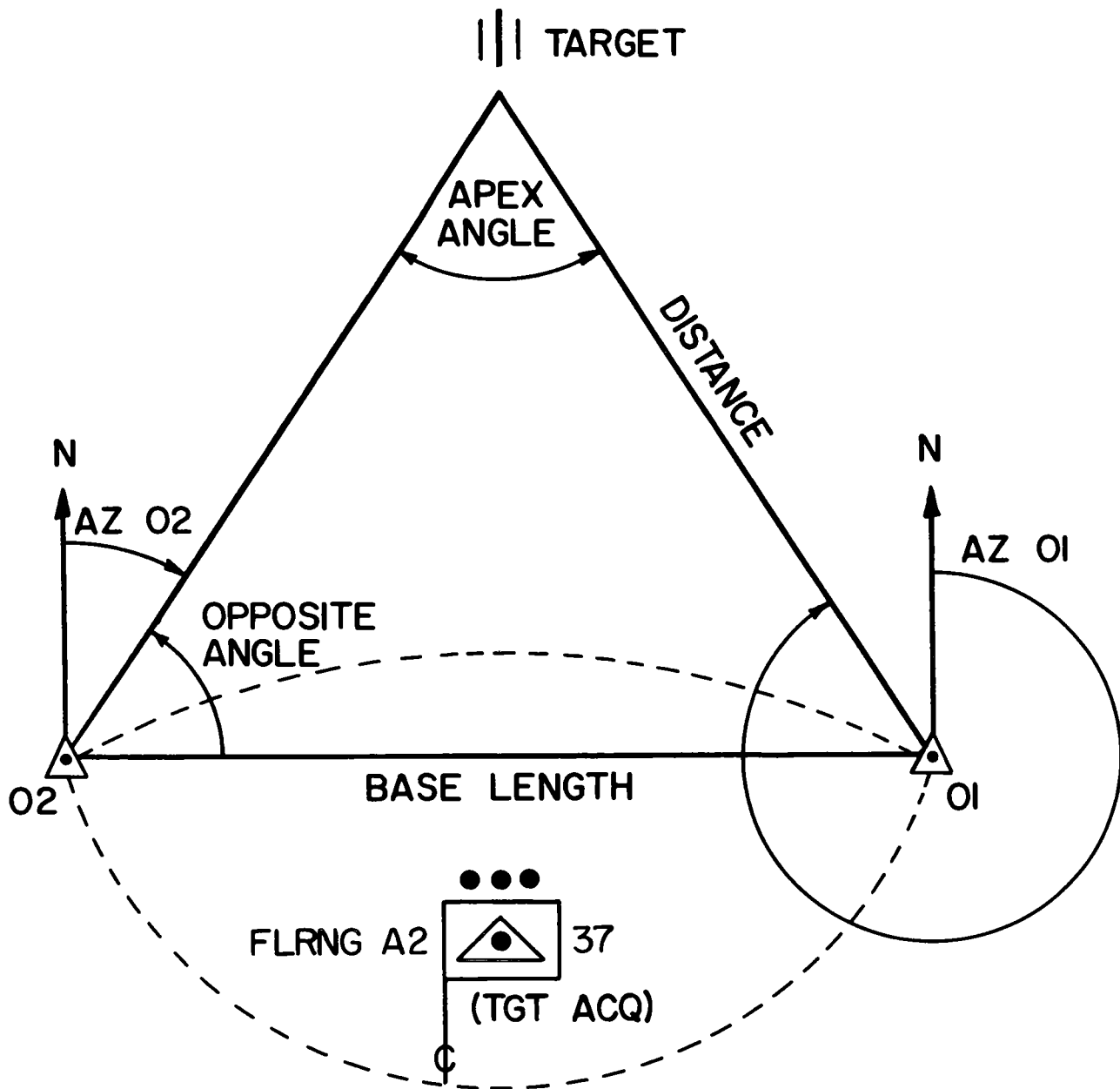


Figure 97. Flash short base operation.

b. Limitations. The short base is subject to the same basic limitations as the long base (para. 126); in addition—

- (1) The short base limits accurate location of targets to a range approximately 7 times the base length. (The minimum acceptable target angle is 150 mils.)
- (2) The short base is restricted to nar-

rower areas of observation than the long base.

- (3) Locations made from a short base are subject to less proof than those made from a long base and are, therefore, normally less reliable.
- (4) If one OP of a short base cannot be operated, the base cannot be operated.

154. Reconnaissance, Selection, and Occupation of Position

The principles which apply to the reconnaissance, selection, and occupation of a long base (para. 127-133) apply equally to the reconnaissance, selection, and occupation of a short base. In addition, the following three conditions should be satisfied in the selection of positions for a short base:

a. Both OP's must afford observation throughout the same area in the assigned zone of observation.

b. An effort should be made to obtain inter-visible OP's.

c. The base length selected must be such that the minimum apex (target) angle at maximum target distances will be at least 150 mils. A base length to target distance ratio of 1 to 7

will fulfill this requirement. If the apex angle is smaller than 150 mils, very small pointing errors by the observers or small errors in the use of the slide rule will cause large errors in the determination of the target location.

155. Communications

Immediately on completion of the reconnaissance and selection of positions, cables are laid from the short base CP to each OP. When these cables have been installed, a line connecting the OP's is laid, completing a cable loop between the two OP's and the CP. The advantage of a cable loop is that a single break in the cable will not disrupt cable communications. An FM radio is furnished each OP and the CP to provide an initial and alternate means of communication.

Section II. SURVEY

156. Survey Requirements

Several elements of survey data must be determined before the short base can be operated—the base length and azimuth and an azimuth from each OP to a visible point (so that the observers can orient their instrument on grid north). The base length is determined to an accuracy of 1:500, and orienting data is determined to the nearest 1.0 mil. The short base survey will be tied in with common survey control as soon as the situation permits. If common control is not readily available, approximate common control may be determined by scaling 01 and an azimuth from a map.

157. Base Length Determination

All of the survey procedures involved in base length determination are covered in FM 6-2. The simplest and most rapid survey method that is adaptable to the terrain and tactical situation should be used. The survey methods available and the situations in which they should be employed are discussed in *a* through *e* below.

a. *Direct Taping Method.* Direct taping is the simplest method of determining base lengths. The base length is taped to an accuracy of 1:500. The distance between the OP's may be taped when—

- (1) The two OP's are intervisible.
- (2) The intervening terrain is suitable for taping.
- (3) The base is an area not under direct observation by the enemy.

b. *Triangulation Method, Single Triangle.* A single triangle may be used to arrive at the base length (1, fig. 98) when—

- (1) The OP's are intervisible.
- (2) The intervening terrain is not suitable for taping (impassable, excessive in distance, or exposed to hostile observation).
- (3) There is suitable terrain for the establishment of an auxiliary base adjacent to one of the OP's.

c. *Triangulation Method, Quadrilateral, With Intervisible OP's.* A quadrilateral may be used to determine base length (2, fig. 98) when—

- (1) The OP's are intervisible.
- (2) The intervening terrain is not suitable for taping.
- (3) The terrain adjacent to the OP's does not permit the establishment of auxiliary basis.
- (4) The terrain to the front or rear of the base is suitable for the installation of an auxiliary base.
- (5) Both ends of the auxiliary base are visible from one OP and at least one

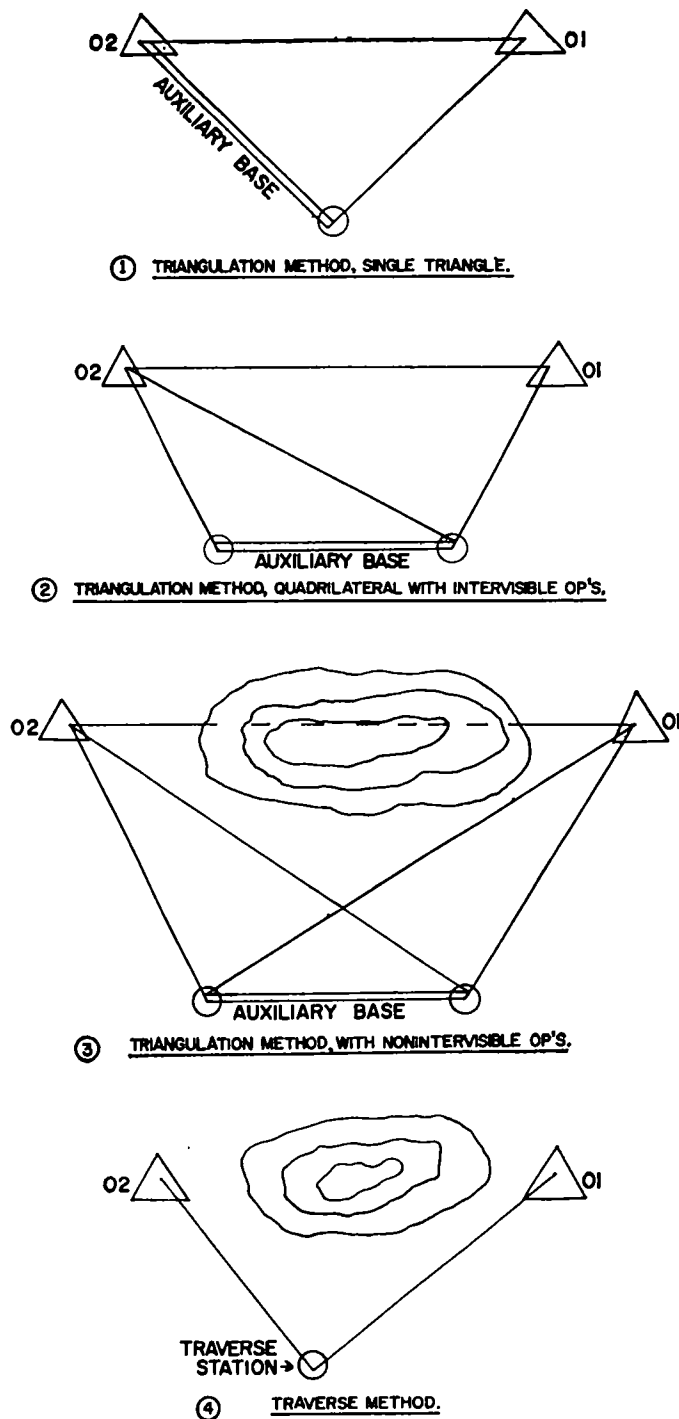


Figure 98. Methods of base length determination.

end of the auxiliary base is visible from the other OP.

d. Triangulation Method, Quadrilateral, With Nonintervisible OP's. A quadrilateral may be

used to determine the base length (3, fig. 98) when—

- (1) The OP's are not intervisible.
- (2) The terrain adjacent to the OP's does

not permit the establishment of auxiliary bases.

- (3) The terrain to the front or rear of the base is suitable for the installation of an auxiliary base.
- (4) Both ends of the auxiliary base are visible from both OP's.

e. Traverse Method. A traverse may be used to determine the base length (4, fig. 98) when—

- (1) The OP's are not intervisible.
- (2) It is impossible to install an auxiliary base.
- (3) The terrain permits the use of two or more traverse legs to connect the OP's.

158. Orientation

The observer at each OP must be furnished the grid azimuth to a known point in order to orient his observing instrument on grid north. When survey control is available, direction will also be available. When survey control is not available, direction may be established by either direct or indirect orientation.

a. Direct Orientation. When both OP's are intervisible, direct orientation can be accomplished as follows:

- (1) The azimuth of the base is determined by the best means available (para. 137c).
- (2) The observer at the OP from which the azimuth of the base is measured sets the azimuth on his instrument while sighting on the other OP.
- (3) The observer at the other OP sets the determined azimuth $\pm 3,200$ mils on his instrument and sights on the first OP.
- (4) Both observers are now oriented.

b. Indirect Orientation. When the OP's are not intervisible, they must be oriented by indirect orientation. Indirect orientation can be accomplished by determining an azimuth from one OP by the best means available (para. 137c) and carrying through the survey scheme to the other OP.

Section III. OPERATING PROCEDURES

159. General

a. Observation Post Procedures. Personnel, equipment, and operating procedures of the OP's of this short base are the same as those of the long base (para. 137).

b. Command Post Procedures.

- (1) *Duties of personnel.* The number of personnel in the short base CP is flexible. The flash chief (or an NCO designated by the flash platoon commander) supervises all operations of the short base. One or more computers perform necessary computations. A draftsman-plotter normally constructs the plotting charts and performs all plotting. A computer, draftsman-plotter, or radiotelephone operator is designated to operate the CP telephones, performing the same duties as the switchboard operator at the long base CP when appropriate. A computer, draftsman-plotter, or radiotelephone operator is designated as re-

corder and enters all pertinent data on the short base flash ranging record (para. 138).

- (2) *Equipment.* The CP is equipped with at least the following items: A range-deflection protractor, plotting charts and plotting equipment, a military slide rule, logarithmic tables, two field telephones, and an FM radio.
- (3) *Orientation.* The procedures for orienting the observers of a short base are the same procedures for orienting the observers of a long base (para. 139).
- (4) *Observation post reports.* The telephone operator receives target reports from the observers and issues the appropriate commands (para. 138).
- (5) *Computing, plotting, and reporting of targets.* Targets are computed, plotted, and reported as discussed in paragraphs 160 through 165. General instructions regarding plotting equipment and plotting techniques will be found in FM 6-40.

160. The Short Base Flash Ranging Record

The individual designated as recorder will enter all data on the Short Base Flash Ranging Record, DA Form 6-3b (fig. 99), as follows:

a. *AZ 02-01*. The azimuth of the base, ± 3200 mils, as determined by survey is entered to the nearest 0.5 mil.

b. *AZ 02-T*. The azimuth to the target and accuracy of reading as reported by O_o. (Note that this is recorded in both columns.)

c. *AZ 01-T*. The azimuth to the target and accuracy of reading as reported by 01.

d. *OPP <*. The opposite angle is determined by subtracting the azimuth 02 from the azimuth 02-01.

e. *Apex <*. The apex angle is determined by subtracting the azimuth 01-T from the azimuth 02-T.

f. *Base Length*. The base length as determined by survey is entered to the nearest meter.

g. *Distance 01 to Target*. The distance from 01 to the target is computed by the use of the slide rule and is polar plotted from 01 on the plotting chart.

h. *Vert < to T at 01*. The vertical angle to the target as reported by 01.

i. *Height of 01*. The height of 01 as determined by survey is entered to the nearest meter.

j. *dH $\pm$* . The difference in height between 01 and the target is computed on the sine-tangent function scale of the military slide rule to the nearest 0.1 meter.

k. *Height (of Target)*. Height of target is computed to the nearest meter.

l. *Location of Target*. If the short base is on common survey control, the grid references to the nearest 10 meters, will be recorded and reported to higher headquarters.

m. *File Numbers and Time Reported*. A file number is assigned by the flash platoon commander or NCO in charge of the short base CP to identify each target location. The file numbers run consecutively for an entire day. The time reported is the time the location is reported to higher headquarters.

n. *Accuracy*. The accuracy of the location reported is based on accuracy of survey, OP readings, and distance to target. If the apex

angle is greater than 150 mils, the accuracy should be within 50 meters and should be reported as such.

o. *Time Observed*. The time the gun was actually firing.

p. *Nature of Target*. Artillery weapons are grouped as light, medium, heavy, or very heavy. The target is described briefly but in sufficient detail for the FDO to determine the amount and type of ammunition to expend on it.

q. *Remarks (Area Shelled, Control)*. If the flash platoon personnel know the area shelled, the coordinates of the area are entered. If the area shelled is not known, the word "unknown" is entered.

r. *Conc No*. A concentration number is assigned by the unit firing on the target and that number is entered in this space. The concentration number may be placed at the target location on the plotting chart for reference in the event future activity is observed at that location.

161. Computations for Plotting Targets

a. In order to polar plot a target location on either the gridded or ungridded chart, three elements of the data must be determined—a point of origin for plotting, the direction from the point of origin to the target, and the distance from the point of origin to the target.

(1) *Point of origin*. The right OP (01) is always the point of origin used for short base plotting.

(2) *Direction to target*. The azimuth reported by the observer at 01 in his report to the CP is the direction to the target.

(3) *Distance to target*. The distance from 01 to the target is determined by solving a sine law equation with the military slide rule (*b* below).

b. The distance from 01 to the target is computed with the military slide rule by solving the following equation and using procedures outlined in (1) through (3) below and in TM 6-240:

$$\frac{\text{distance}}{\sin \text{ of opposite angle}} = \frac{\text{base length}}{\sin \text{ of apex angle}}$$

(1) Base length is determined by survey to an accuracy of 1:500.

SHORT BASE FLASH RANGING RECORD (FM 6-22)						DATE	
AZ 02 - OI <u>3192.0</u> + <u>6400.0</u> SUM <u>3192.0</u> AZ 02 - T- <u>1745.0</u> <u>A</u>		AZ 02 - OI <u>3192.0</u> + <u>6400.0</u> SUM _____ AZ 02 - T- _____ + <u>6400.0</u> SUM _____ AZ 01 - T- _____ <u>A</u>		AZ 02 - OI <u>3192.0</u> + <u>6400.0</u> SUM _____ AZ 02 - T- _____ + <u>6400.0</u> SUM _____ AZ 01 - T- _____ <u>A</u>		AZ 02 - T _____ + <u>6400.0</u> SUM _____ AZ 01 - T- _____ <u>A</u>	
(4 AT 02) OPP <u>1447.0</u>		(4 AT T) APEX <u>262.0</u>		(4 AT 02) OPP _____		(4 AT T) APEX _____	
BASE LENGTH <u>1399</u> YDS <u>M</u>		DISTANCE (OI - T) <u>5430</u> YDS <u>M</u>		BASE LENGTH <u>1399</u> YDS <u>M</u>		DISTANCE (OI - T) _____ YDS <u>M</u>	
TARGET LOCATION <u>52452355</u>		VERT $\frac{1}{2}$ TOT AT OI <u>4.0</u> HEIGHT OI <u>415.0</u> DIST $\times$ VERT $\frac{1}{2}$ = 1000 <u>21.3</u> <u>436.3</u> HEIGHT T <u>436.0</u>		VERT $\frac{1}{2}$ TOT AT OI _____ HEIGHT OI <u>415.0</u> DIST $\times$ VERT $\frac{1}{2}$ = 1000 _____ HEIGHT T _____		VERT $\frac{1}{2}$ TOT AT OI _____ HEIGHT OI <u>415.0</u> DIST $\times$ VERT $\frac{1}{2}$ = 1000 _____ HEIGHT T _____	
FILE NO. & TIME REPORTED <u>15</u> <u>0935</u>	ACCURACY (METERS) <u>50</u>	TIME ACTIVE FROM <u>0930</u> TO <u>0932</u>	NATURE OF TARGET (TO INCLUDE CALIBER) <u>HVY GUN</u>	FILE NO. & TIME REPORTED _____	ACCURACY (METERS) _____	TIME ACTIVE FROM _____ TO _____	NATURE OF TARGET (TO INCLUDE CALIBER) _____
REMARKS (AREA SHELLED, CONTROL) <u>470 215</u>		CONC NO. _____		REMARKS (AREA SHELLED, CONTROL) _____		CONC NO. _____	

DA FORM 6-3b
OCT 55

PREVIOUS EDITIONS OF THIS FORM ARE OBSOLETE.

GPO 817136

Figure 99. A completed Short Base Flash Ranging Record, DA Form 6-3b.

- (2) The value of the apex angle is determined by subtracting the azimuth reported from 01 from that reported from 02 (plus 6,400 mils, if necessary).
- (3) The opposite angle is equal to the azimuth 02-01 (plus 6,400 mils, if necessary) minus the azimuth reported from 02.

c. An example of the computation for distance on the short base flash ranging record (fig. 99) is as follows:

01: 1483 ALFA, PLUS 4, HEAVY GUN

02: 1745 ALFA, HEAVY GUN

The base length is 1,399 meters; the azimuth from 01 to 02 is 6,392 mils. Solution for the elements of data follows:

- (1) The direction to the target is the azimuth from 01 to the target: 1,483 mils.
- (2) The apex angle is equal to the azimuth from 02 to the target minus the azimuth from 01 to the target: 1,745 — 1,483 = 262 mils.
- (3) The opposite angle is equal to the azimuth from 02 to 01 minus the azimuth from 02 to the target: 3,192 — 1,745 = 1,447 mils.
- (4) Distance is then determined by solving the following equation with the military slide rule:

$$\frac{\text{distance}}{\sin 1447} = \frac{1399}{\sin 262}$$

- (5) Distance = 5,430 meters.

d. Computations for plotting targets are also performed on the short base flash ranging record (fig. 99).

162. Ungridded Short Base Chart

When common survey control between the short base and firing units is not available, an ungridded chart is constructed on a plain sheet of paper as follows (fig. 100):

a. For convenience in plotting targets, 01 is plotted at the bottom center of the chart, with the short axis of the chart extending away from the draftsman-plotter. Since common survey control is not available, the exact position of 01 on the chart is not important.

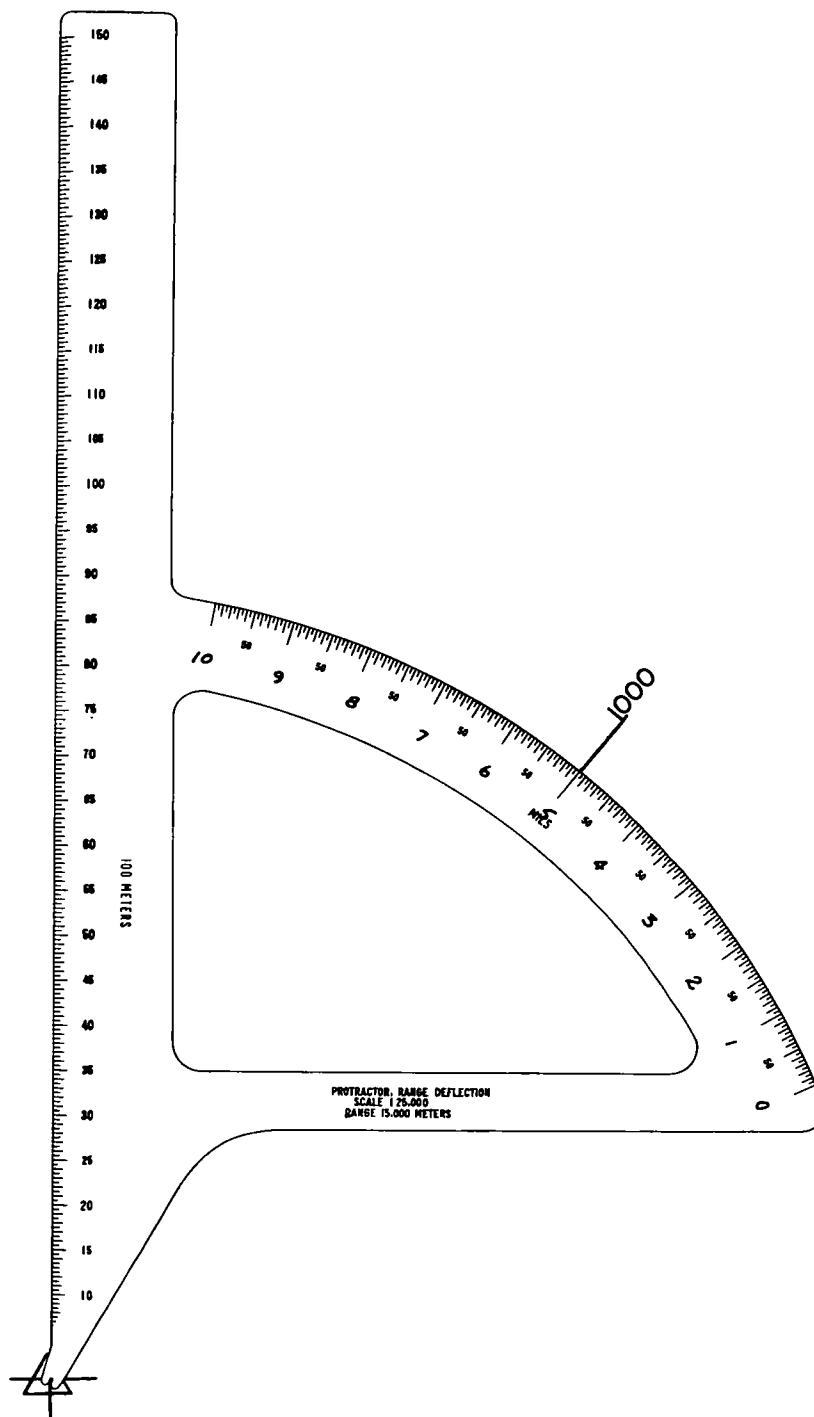
b. So that the target area will be in the upper center of the chart, reference lines are established and labeled as follows:

- (1) The direction of ranging is determined by adding 1,600 mils to the azimuth of the base (01-02), subtracting 6,400 from the sum, if necessary, and rounding the result off to the nearest 100 mils.
- (2) The vertex of the range-deflection protractor is placed at the plotted location of 01, and the left edge of the protractor is placed at the top center of the chart.
- (3) Tick marks are made on the chart at even 1,000-mil intervals, using the mils scale of the protractor. The tick marks are labeled so that the upper center of the chart will represent the direction of ranging.

c. The following example describes the procedures for establishing ungridded short base chart:

- (1) The azimuth 01-02 is measured with an M2 compass as 6,340 mils.
- (2) The direction of ranging is 6,340 mils plus 1,600 mils, or 7,940 mils. Since this sum exceeds 6,400, it is necessary to subtract 6,400 mils: 7,940 — 6,400 = 1,540 mils.
- (3) The direction of ranging, 1,540 mils, is rounded off to the nearest 100 mils: 1,500 mils.
- (4) The mil scale on the protractor is numbered from 0 to 1,000 mils, beginning at the 0-mil index on the far right of the scale.
- (5) 01 is plotted at the bottom center of the chart.
- (6) The vertex of the protractor is placed at the plotted location of 01, and the left edge of the protractor is placed at the top center of the chart.
- (7) A reference line is placed on the chart at the 500-mil mark of the protractor scale and labeled as the 1,000-mil reference line. The reference line should be drawn 1 inch above and below the edge of the protractor.
- (8) Additional reference lines are established 1,000 mils right and left of the first reference line and labeled 2,000 mils and 0 mils, respectively.

AZ 0



AZ 2000

Figure 100. Ungridded short base chart.

(9) The base length and azimuth of the base and the height of 01 are entered in the lower right-hand corner of the plotting chart.

d. When the ungridded short base chart is in use, the only mission the flash platoon can accomplish is the adjustment of friendly artillery.

163. Gridded Short Base Chart

When common survey control is available, a gridded plotting chart should be used (fig. 101) since reporting target location by grid reference is the most accurate and rapid method.

a. As on the ungridded chart, the top center of the gridded chart represents the direction of ranging. This direction is used to determine the proper orientation of the chart, and the grid lines are numbered so that 01 is plotted at the bottom center of the chart.

b. Reference lines are established on the gridded chart by using the cardinal direction of ranging (0, 1,600, 3,200, 4,800). The cardinal direction is determined and used as a central reference line (not drawn) to establish indexes at 1,000-mil intervals covering the target area.

c. The following example describes the procedures for establishing a gridded short base chart:

- (1) The surveyed coordinates of 01 are (34585.0-64629.5).
- (2) The azimuth of the base (01-02) is 3,164 mils.
- (3) The direction of ranging is 3,164 mils plus 1,600 mils, or 4,764 mils.
- (4) The cardinal direction of ranging is west, or 4,800 mils, and the top of the chart is designated as west.
- (5) 01 is plotted at the lower center of the chart. The selected grid square is labeled as the 3464 grid square. The grid system is then numbered (increasing to the north and east).
- (6) A reference line is placed on the chart at the 800-mil mark on the protractor scale and labeled as the 4,000-mil reference line.
- (7) Indexes are constructed as discussed in FM 6-40.

164. Plotting Targets

Target locations are polar plotted, on both the gridded and ungridded charts, from the location of 01 as follows:

a. The azimuth reported from 01 is reproduced by offsetting the range-deflection protractor the necessary number of mils to the right of the appropriate 1,000-mil reference lines so that

the left edge of the fan is on the proper azimuth.

b. A plotting needle is inserted in the chart along the edge of the protractor at the 01-target distance.

c. The target position is marked with a tick mark and designated as follows:

- (1) The file number assigned the target location is entered in the upper right quadrant.
- (2) The concentration number, if any, is also entered in the upper right quadrant.
- (3) The target height, when determined, is entered to the nearest meter in the bottom left quadrant.

165. Reporting of Target Locations

Target locations plotted on the ungridded chart will be reported by polar coordinates or by a shift from a known point by using target grid procedures. Target locations plotted on the gridded chart will be reported by grid reference.

a. *Polar Coordinates.* When a target location is reported by polar coordinates, the azimuth, distance, and vertical angle to the target from a known point must be reported.

- (1) The location of the known point (01) must be plotted on the firing unit's firing chart. Since common survey control is not available, 01 is most easily located by back-plotting from a chosen point, located on the firing chart, which is visible to both observers. The azimuth and distance from 01 to the chosen point are determined, and the firing unit plots 01 on the back-azimuth at the reported distance.
- (2) The azimuth and distance reported are those which established the target location on the flash plotting chart.
- (3) The vertical angle is the vertical angle from 01 to the target.

b. *Shift From a Known Point.* When a target location is reported by a shift from a known point the same procedures used for observed fire (FM 6-40) are used. Shifts from a known point are measured from the flash plotting chart in order to bring fire on the target. This is accomplished as follows:

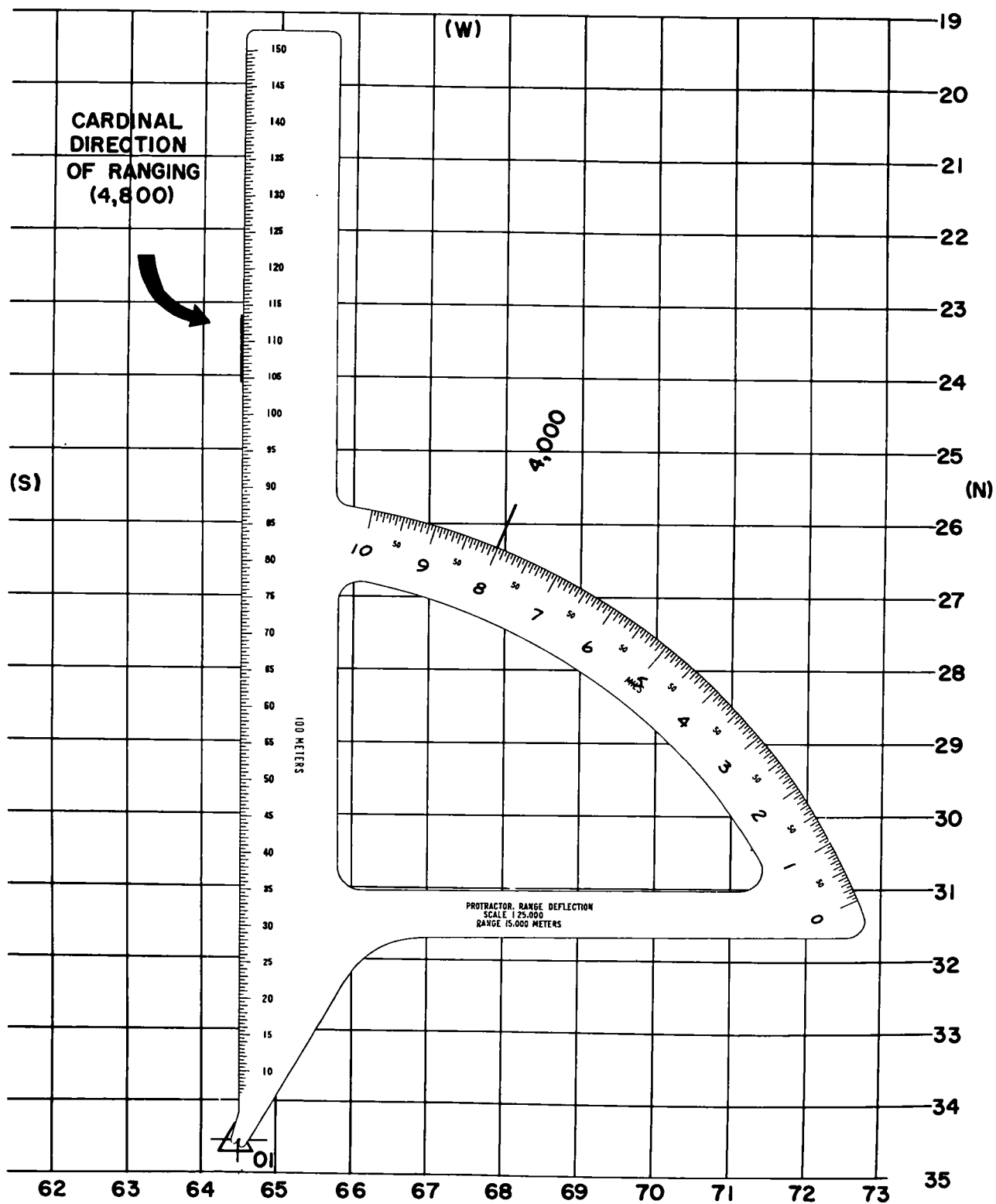


Figure 101. Gridded short base chart.

- (1) A common known point must be plotted on the charts of the flash platoon and the firing unit. This point may be one of the firing battalion's registration points, or it may be the point of impact of several rounds fired from a weapon of the firing unit, located by flash ranging procedures, and plotted on the flash plotting chart.
- (2) The target is located with respect to

the point established in (1) above by measuring the shift. The initial fire request is rendered as described in FM 6-40.

c. Grid Reference. Reporting a target location by grid reference is the most accurate and rapid means of reporting target locations plotted on the gridded chart, although polar coordinates or a shift from a known point can also be used.

PART THREE
INSTRUCTIONS COMMON TO BOTH SOUND RANGING AND FLASH RANGING
CHAPTER 20
MAINTENANCE AND INSPECTIONS

166. General

Maintenance is essential to insure that the platoon is prepared to carry out its mission immediately. Systematic maintenance drills provide the best insurance against unexpected breakdown at a critical moment when maximum performance is essential.

167. Disassembly, Adjustment, and Assembly

a. Sound Ranging Equipment. Disassemblies and adjustments of the recorder, power supply, and microphones authorized to be performed by battery personnel are prescribed in TM 11-2568. No deviation from the procedures outlined in the manual is permitted unless authorized by the responsible signal maintenance officer.

b. Flash Ranging Equipment. For instructions concerning the disassembly and adjustment of the flash ranging set authorized to be performed by battery personnel, see TM 11-5516; for disassembly and adjustment of the flash ranging plotting board, see TM 9-6109; for disassembly and adjustment of observing instruments, see TM 9-575.

168. Records

a. The principal forms pertaining to the materiel are the field report of accidents (AR 385-63), the Maintenance Request (DA Form 2407) (AR 750-5), and equipment maintenance records (TM 38-750). Information on the purpose and use of these forms is included on the forms.

b. The chiefs of sections, platoon leaders, and battery commander also should keep semi-

permanent records for information and guidance.

169. Maintenance

a. Sound Ranging Equipment. For detailed instructions concerning maintenance of the sound ranging set, see TM 11-2568.

b. Flash Ranging Equipment. For detailed instructions concerning maintenance of the flash ranging set, see TM 11-5516; for maintenance of the flash ranging plotting board, see TM 9-6109; for maintenance of the observing instruments, see TM 9-575.

170. Inspections

Regular inspections are required to insure that materiel is maintained in serviceable condition.

a. The chief of section is responsible for the equipment within the section. He should inspect the equipment thoroughly each day. If he sees the need for repair or adjustment, he should notify the platoon commander immediately so that the necessary action may be taken.

b. The platoon commander, accompanied by the senior noncommissioned officer, should make a daily spot check inspection. He should inspect different items of materiel each day to insure complete coverage every few days. At least once a month, the platoon commander should make a thorough mechanical inspection of all platoon equipment.

c. For details on inspecting the sound ranging set, see TM 11-2568. For details on inspecting flash ranging equipment, see TM 9-575, TM 9-6109, and TM 11-5516.

d. Deficiencies found during inspections should be remedied immediately.

CHAPTER 21

DECONTAMINATION OF EQUIPMENT

171. General

Equipment which has been contaminated by chemical, biological, or radiological agents constitutes a danger to personnel. *Contamination* is the act of spreading an injurious agent in any form and by any means. Persons, objects, or terrain can be contaminated. *Decontamination* is the process of making any contaminated place or object safe for unprotected personnel. This can be done by covering, removing, destroying, or changing into harmless substances the contaminating agent or agents. Generally, only equipment contaminated by persistent agents needs to be decontaminated.

172. Decontamination for Chemical Agents

a. Sound Ranging Set. With rags, wipe off visible contaminant from the recorder, power supply, and microphones. Apply DANC (decontamination agent noncorrosive M4). If DANC is not available, scrub the equipment with soap and cool water.

b. Instruments and Plotting Equipment. If instruments and plotting equipment are exposed to corrosive gases, clean them as soon as possible with alcohol (or gasoline, if no alcohol is available) and apply a thin coat of light machine oil. A rag dampened with DANC may be used, followed by drying with a clean rag and then applying a coat of machine oil. DANC injures plastic or hard rubber surfaces.

c. Ammunition. With rags, wipe visible contaminant from ammunition. Apply DANC, wipe with gasoline-soaked rag, and then dry. If DANC is not available, scrub ammunition with soap and cool water. Slurry (equal weights of water and chloride of lime) can be used on contaminated ammunition containers, but it must not be allowed to penetrate into the ammunition itself. Small-arms ammunition cannot be decontaminated practicably. In an emergency, the above methods may be employed. Normally,

however, the only practical method of decontaminating small-arms ammunition is by aeration; that is, exposure to air and other weather elements.

d. Weapons. Remove dirt, dust, grease, and oil from weapons. Do not apply wet mix but allow surfaces to air after oil and dirt have been removed. DANC can be used on all metal surfaces except the bore. Also effective on metal are hot water, cleaning solvent, or repeated applications of gasoline on swabs. If the emergency use of gasoline-soaked swabs is necessary (FM 21-40), extreme care must be taken to insure that the gasoline does not spread the contaminant and that no gasoline in liquid or vapor form remains. This excess gasoline would be ignited when the weapon is fired. After decontamination, dry and oil the weapons.

e. Automotive Equipment. Automotive equipment lightly contaminated by spray can be decontaminated by aeration alone. For heavier contamination, use DANC on interior and exterior surfaces which personnel are likely to touch. For larger area decontamination, wash the vehicle with water and scrub painted surfaces with soap and water.

173. Decontamination for Biological and Radiological Agents

a. General. After a contaminating attack, recovery of equipment may be achieved either by waiting, to permit the decay of the contaminant, or by action decontamination, to reduce the danger to a level where it is no longer a significant hazard to operating personnel. Decontamination may be either rough or detailed, depending on the urgency of the military situation. The procedure adopted will be a command decision.

b. Rough Decontamination. Rough decontamination is performed when urgency is the main factor. The purpose of rough decontamination

is to reduce contamination sufficiently to permit personnel to work with, or close to, equipment for limited periods. Rough decontamination may be achieved by means of water or steam if available. Soap or another detergent used in conjunction with water or steam aids in decontamination. Care must be taken in the disposal of water used in the decontamination process since it has, in turn, become contaminated.

c. Detailed Decontamination. Detailed decontamination, in which the emphasis is on thoroughness, is carried out in rear areas and repair bases and includes surface decontamination, aging, sealing, and disposal.

174. References

For further information on decontamination, see FM 21-40, TM 3-220, and TF 3-1407.

CHAPTER 22

DESTRUCTION OF EQUIPMENT

175. General

a. Tactical situations may arise in which it is necessary to abandon equipment in the combat zone. In such a situation, all abandoned equipment must be destroyed to prevent its use by the enemy.

b. *The destruction of equipment subject to capture or abandonment in the combat zone will be undertaken only upon authority delegated by a division or higher commander.*

176. Principles

All sections will prepare plans for destroying their equipment in order to reduce the time required should destruction become necessary. The principles of destruction are as follows—

a. Plans for destruction of equipment must be adequate, uniform, and easily carried out in the field.

b. Destruction must be as complete as the available time, equipment, and personnel will permit. Since complete destruction requires considerable time, *priorities* must be established so that the more essential parts are destroyed first.

c. The same essential parts must be destroyed on all like units to prevent the enemy from constructing a complete unit from undamaged parts.

d. Spare parts and accessories must be given the same priorities as the parts installed on the equipment.

177. Methods of Destruction

To destroy equipment adequately and uniformly, all personnel of the unit must know the plan and priority of destruction.

178. Sound Ranging Set

a. *Recorder*—Use an ax or sledge to completely smash electrical equipment, such as meters, switches, and cable receptacles. Break the galvanometer assembly and smash the printing mechanism. Detonate an incendiary grenade inside the recorder.

b. *Plate Supply-Timer*—Use an ax or sledge to completely smash all electrical equipment, such as meters, switches, and cable receptacles. Remove and smash the spare vibrators. Detonate an incendiary grenade inside the timer.

c. *Power Unit*—Use an ax or sledge to completely smash the control panel, switches, meters, and terminals. Detonate an incendiary grenade on top of the engine.

d. *Outpost Unit*—Use an ax or sledge to completely smash the switch, outpost connecting box, and telephone. Heap the debris into a pile, drench with gasoline, and burn.

e. *Microphones*—Remove the microphone case covers and destroy the interior parts with an ax or sledge. Pour gasoline on top of the units and ignite it.

179. Flash Ranging Set

For detailed information on destruction of the flash ranging set, see TM 11-5516.

180. References

For detailed information on destruction of vehicles, see TM 9-8014, TM 9-8024, and TM 9-9030; for destruction of communication equipment, see TM 11-333 and TM 11-5820-292-10; for destruction of ammunition, see TM 9-1900.

CHAPTER 23

TRAINING

Section I. GENERAL

181. Purpose and Scope

The purpose of this chapter is to present the absolute minimum requirements for training the personnel of the sound and flash platoons of the field artillery target acquisition battery *in the subjects discussed in this manual*. It includes general information on the conduct of training and a minimum training schedule.

182. Objectives of Training

The objectives of training are to speed the attainment of proficiency by sound and flash platoon personnel in their individual duties and, through drill, to weld them into an effective, coordinated team able to function effectively in combat. During training, supervisors should keep in mind the proficiency sought by Army Training Test (ATT) 6-577 for the field artillery target acquisition battalion. Maximum efficiency is attained through continuous drills.

183. Conduct of Training

a. Training will be conducted in accordance with the principle set forth in FM 21-5. The goal of training should be the standards set forth in AR 611-201.

b. Individual training is usually conducted by non-commissioned officers as far as practicable. Officers are responsible for preparing training

plans, conducting unit training, and supervising and testing individual training.

c. Throughout training, the application of prior instruction to current training must be emphasized.

d. A record of the training received by each individual should be kept on a progress card by each chief of section for each man in his section. This card should show each period of instruction attended, tests taken, and remarks pertaining to progress. Progress cards should be inspected frequently by the platoon commander to make sure that they are being kept properly and to determine the state of training. *Requiring the chief of section to keep these records emphasizes his responsibility toward his section.*

e. The necessity for developing leadership and initiative in noncommissioned officers must be emphasized constantly throughout training.

f. Additional time, outside the regular training schedule, should be allotted for training individuals in technical specialties.

g. Subjects involving similar time-consuming operations may be combined where practicable. For example, a reconnaissance, selection, and occupation of position may be combined with a road march to move units forward prior to completion of ground reconnaissance.

Section II. MINIMUM TRAINING SCHEDULE

184. General

a. *Sound Platoon.* The training schedule outlined in paragraph 185 is a guide for meeting the minimum training requirements of personnel of a sound platoon in the subjects covered in this manual. TM's 9-575, 9-208-1, 9-208-2, 9-8012, and 11-2568 provide information on

which to base periods of instruction on the description, characteristics, and functioning of the sound ranging set, plotting equipment, and vehicles. *Additional training beyond the scope of this schedule is necessary to develop an efficient and well-trained platoon.*

b. *Flash Platoon.* The training schedule out-

lined in paragraph 186 is a guide for meeting the minimum training requirements of personnel of a flash platoon in the subjects covered in this manual. TM's 9-575, 9-809, 9-208-1, 9-208-2, 9-6109, 9-8012, and 11-5516 provide information on which to base periods of in-

struction on the description, characteristics, and functioning of the flash ranging set, plotting equipment, and vehicles. *Additional training beyond the scope of this schedule is necessary to develop an efficient and well-trained platoon.*

185. Sound Platoon

C—conference; D—demonstration; PW—practical work.

Method	Hours	Subject	Text references	Training aids and equipment
C,D	1-----	Organization and missions of the sound ranging platoon.	Para 2-5, and TF 6-1775.	TOE equipment, blackboard, projector, and screen.
C,D	1-----	Sound waves and sound propagation-----	Para 6-16-----	Blackboard.
C,D	1-----	Theory of sound ranging-----	Para 17-20-----	Blackboard.
C,D	1-----	Elements of a sound ranging installation and selection of position.	Para 25-29-----	Blackboard.
C,D	1-----	Types of sound ranging bases-----	Para 21-24-----	Blackboard.
C,D,PW	4 (2-hour periods).	Sound ranging base computations-----	Para 32-35-----	Blackboard and log books.
C,D,PW	4 (2-hour periods).	Sound ranging base survey-----	Para 36-42-----	Blackboard and TOE equipment.
C,D,PW	6 (2-hour periods).	Sound ranging record interpretation-----	Para 62-67-----	Blackboard and TOE equipment.
C,D,PW	6 (2-hour periods).	Determination and correction of time intervals.	Para 81-88-----	Blackboard, correction charts, and devices.
C,D,PW	4 (2-hour periods).	Calculator method of applying corrections-----	Para 89, 90-----	Blackboard and calculators.
C,D,PW	8 (2-hour periods).	Plotting charts and devices-----	Para 69-80-----	Blackboard and TOE plotting equipment.
C,D,PW	2-----	Plot interpretation-----	Para 91-94-----	Blackboard and TOE plotting equipment.
C,D	1-----	Caliber estimation-----	Para 68-----	Blackboard.
C,D,PW	4-----	Ballistic plotting-----	Para 108-112-----	Blackboard, TOE plotting equipment, and correction charts.
C,D,PW	2-----	Conduct of fire-----	Para 113-118-----	Blackboard and TOE plotting equipment.
C,D,PW	2-----	Reconnaissance for sound ranging installations.	Para 30, 31-----	Blackboard, maps, and plotting equipment.
C,D	2-----	Installation, occupation, and organization of sound ranging installations.	Para 43-58-----	Blackboard and TOE equipment.
C,D	1-----	Duties of personnel and equipment of sound ranging observation post.	Para 59-61-----	Blackboard and TOE equipment.
C,D,PW	2-----	Operation of a sound ranging command post.	Para 95-107-----	Blackboard and TOE equipment.
PW	12 (4-hour periods).	Sound ranging command post exercise-----	Review all previous references.	TOE equipment.
PW	4-----	Field exercise in reconnaissance and selection of sound ranging installation positions.	Para 25-31-----	Maps and plotting equipment.
PW	16 (4-hour periods).	Field exercise in selection, occupation, and operation of a sound ranging base by using rapid survey methods.	Review all previous references.	TOE equipment.
PW	16 (4-hour periods).	Field exercise in occupation and operation of a sound ranging base (weapon location).	Review all previous references.	TOE equipment.
PW	8 (4-hour periods).	Field exercise in occupation and operation of a sound ranging base (conduct of fire).	Review all previous references.	TOE equipment.

Method	Hours	Subject	Text references	Training aids and equipment
PW	8 (4-hour periods).	Field exercise in ballistic plotting.....	Review all previous references.	TOE equipment.
C,D,PW	1.....	Decontamination of equipment.....	Para 171-174.....	TOE equipment.
C,D,PW	1.....	Destruction of equipment to prevent use by the enemy.	Para 175-180.....	TOE equipment.
C,PW	4.....	Review of subjects previously covered.....	All previous references.	TOE equipment.

186. Flash Platoon

C—conference; D—demonstration; PW—practical work.

Method	Hours	Subject	Text references	Training aids and equipment
C,D	1.....	Organization and missions of the flash platoon.	Para 120-122, and TF 6-2258.	TOE equipment, blackboard, projector, and screen.
C,D	1.....	Duties of personnel.....	Para 123.....	Blackboard and TOE equipment.
C,D	1.....	Description and operation of a flash long base.	Para 124-127.....	Blackboard.
C,D,PW	4.....	Reconnaissance, selection, and occupation of a flash long base.	Para 128-133.....	Blackboard and maps.
C,D,PW	2.....	Flash observation post procedures.....	Para 137.....	Blackboard and TOE equipment.
C,D,PW	2.....	Operation of flash ranging plotting board.....	Para 140-143, and 146.	Flash ranging plotting board.
C,D,PW	4.....	Survey of flash observation posts.....	Para 134-136.....	Blackboard and TOE equipment.
C,D,PW	4.....	Locating observation posts by using flash ranging plotting board.	Para 142-144.....	Blackboard and flash ranging plotting board.
C,D,PW	1.....	Polygon of error.....	Para 146.....	Blackboard and flash ranging plotting board.
C,D,PW	2.....	Flash long base command post procedures.....	Para 138.....	Blackboard and TOE equipment.
C,D,PW	4 (2-hour periods).	Conduct of fire by a flash long base.....	Para 147-150.....	Blackboard and TOE equipment.
PW	8 (4-hour periods).	Flash long base command post exercise.....	Review all previous references.	TOE equipment.
C,D	1.....	Description and operation of a flash short base.	Para 151-153.....	Blackboard.
C,D,PW	4.....	Reconnaissance, selection, and occupation of a flash short base.	Para 154, 155.....	Blackboard and maps.
C,D,PW	4 (2-hour periods).	Flash short base survey methods.....	Para 156-158.....	Blackboard and TOE equipment.
C,D,PW	2.....	Operation of a flash short base.....	Para 159, 160.....	Blackboard and TOE equipment.
C,D,PW	4 (2-hour periods).	Flash short base plotting charts.....	Para 162-165.....	Blackboard and plotting equipment.
C,D,PW	2.....	Computations for plotting targets.....	Para 161.....	Blackboard and slide rules
C,D	1.....	Conduct of fire by a flash short base.....	Para 147-150.....	Blackboard and plotting equipment.
PW	8 (4-hour periods).	Flash short base command post exercise.....	Review all previous references.	TOE equipment.
PW	12 (4-hour periods).	Field exercise in selection, occupation, and operation of a flash short base.	Review all previous references.	TOE equipment.

Method	Hours	Subject	Text references	Training aids and equipment
PW	12 (4-hour periods).	Field exercise in occupation and operation of a flash long base.	Review all previous references.	TOE equipment.
PW	24 (8-hour periods).	Field exercise in selection, occupation, and operation of a flash short base with conversion to long base (weapon location and conduct of fire with both types of bases).	Review all previous references.	TOE equipment.
C,D,PW	1-----	Decontamination of equipment-----	Para 171-174-----	TOE equipment.
C,D,PW	1-----	Destruction of equipment to prevent use by the enemy.	Para 175-180-----	TOE equipment.
C,PW	4-----	Review of subjects previously covered-----	All previous references.	TOE equipment.

APPENDIX I

REFERENCES

1. Miscellaneous Publications

AR 320-5	Dictionary of United States Army Terms.
AR 320-50	Authorized Abbreviations and Brevity Codes.
AR 385-63	Regulations for Firing Ammunition for Training, Target Practice, and Combat.
AR 600-20	Army Command Policy and Procedure.
AR 611-201	Manual of Enlisted Military Occupational Specialties.
AR 672-5-1	Awards.
AR 750-5	Organization, Policies and Responsibilities for Maintenance Operations.
ATP 6-575	Army Training Program for Field Artillery Target Acquisition Battalion.
ATP 6-577	Army Training Program for Lettered Batteries, Field Artillery Target Acquisition Battalion.
DA Pam 108-1	Index of Army Motion Pictures, Filmstrips, Slides and Phono-Recordings.
DA Pam 310-series	Index of Military Publications (as applicable).
TOE 6-577E	Field Artillery Target Acquisition Battery.
FM 5-15	Field Fortifications.
FM 5-20	Camouflage, Basic Principles, and Field Camouflage.
FM 5-25	Explosives and Demolitions.
FM 6-2	Artillery Survey.
FM 6-10	Field Artillery Communications.
FM 6-15	Artillery Meteorology.
FM 6-16	Tables for Artillery Meteorology.
FM 6-20-1	Field Artillery Tactics.
FM 6-20-2	Field Artillery Techniques.
FM 6-40	Field Artillery Cannon Gunnery.
FM 6-120	The Field Artillery Target Acquisition Battalion and Batteries.
FM 6-121	Field Artillery Target Acquisition.
FM 6-125	Qualification Tests for Specialists, Field Artillery.
FM 6-140	The Field Artillery Battery.
FM 7-24	Communication in Infantry and Airborne Divisions.
FM 17-70	Communication for Armor Units.
FM 21-5	Military Training.
FM 21-6	Techniques of Military Instruction.
FM 21-26	Map Reading.
FM 21-30	Military Symbols.
FM 21-40	Small Unit Procedures in Chemical, Biological, and Radiological (CBR) Operations.
FM 21-60	Visual Signals.
FM 22-5	Drills and Ceremonies.

FM 23-65	Browning Machine Gun, Caliber .50, HB, M2.
FM 24-20	Field Wire and Field Cable Techniques.
FM 55-30	Motor Transportation, Operations.
TM 3-220	Chemical, Biological, and Radiological (CBR) Decontamination.
TM 6-240	Slide Rule, Military, Field Artillery.
TM 9-208-1	Cleaning of Ordnance Materiel.
TM 9-208-2	Cleaning, Drying, and Abrading Equipment for Cleaning Ordnance Materiel.
TM 9-238	Deepwater Fording of Ordnance Materiel.
TM 9-500	Ordnance Corps Equipment Data Sheets.
TM 9-575	Auxiliary Sighting and Fire Control Equipment.
TM 9-809	Truck, 2½-ton, 6 x 6 Mod AFKW-353.
TM 9-1900	Ammunition, General.
TM 9-6109	Ordnance maintenance: Plotting Boards M5 and M5A2; Sound Ranging Plotting Boards M1 and M1A1; and Sound Ranging Wind Corrector M1.
TM 9-8012	Operational and Organizational Maintenance: ¼-ton, 4 x 4, Utility Truck M38.
TM 9-8014	¼-ton, 4 x 4, Utility Truck, M38A1.
TM 9-8024	2½-ton, 6 x 6, Cargo Truck M135 and M211.
TM 9-8030	¾-ton, 4 x 4, Cargo Truck M37.
TM 11-333	Telephones EE-8, EE-8-A, and EE-8-B.
TM 11-611	Radio Sets AN/VRC-16, AN/VRC-17, and AN VRC-18.
TM 11-615	Radio Sets SCR-609-A, -B, SCR-610-A, -B, and AN/TRC-20.
TM 11-2568	Sound Ranging Set GR-8.
TM 11-5516	Flash Ranging Set AN/GTC-1.
TM 11-5820-292-10, -20	Radio Sets AN/PRC-8, -8A, -9, -9A, -10, -10A, and -28.
TM 21-300	Driver Selection and Training (Wheeled Vehicles).
TM 21-305	Manual for the Wheeled Vehicle Driver.
TM 38-750	The Army Equipment Record System and Procedures.

2. DA Ord Supply Manuals

ORD 3 SNL K-1	Abrasives, Adhesives, Cleaners, Preservatives, Recoil Fluids, Special Oils, and Related Items.
ORD 3 SNL R-7	Demolition Explosives and Related Items.
SM 9-5-1345	Land Mines and Components.
SM 9-5-1370	Pyrotechnics, Military, All Types.

3. DA and DD Forms

DA Form 2400	Equipment Utilization Record.
DA Form 2407	Maintenance Request.
DA Form 6-1	Computation—Azimuth and Distance From Coordinates.
DA Form 6-2	Computation—Coordinates and Height From Azimuth, Distance, and Vertical Angle.
DA Form 6-3	Orienting Data for Flash Ranging Observation Posts.
DA Form 6-3a	Flash Ranging Record.
DA Form 6-3b	Short Base Flash Ranging Record.
DA Form 6-4	Sound Plotting Record.
DA Form 6-6	Record of Sound, Flash, and Radar Locations.
DA Form 6-29	Flash Observation Post Recording Book.

4. Training Films

TF 3-1407

TF 6-1775

TF 6-2258

Decontamination Procedure—Part I: Basic Techniques.

Field Artillery Sound Ranging.

Organization and Mission of the Flash Platoon.

APPENDIX II

CONVERSION TABLES USED IN SOUND RANGING

Table I. Conversion of Yards to Sound Seconds

Yards	Sound seconds	Yards	Sound seconds	Yards	Sound seconds	Yards	Sound seconds	Yards	Sound seconds	Yards	Sound seconds	Yards	Sound seconds
100	0.271	1,600	4.334	3,100	8.397	4,600	12.459	6,100	16.522	7,600	20.585	9,100	24.648
200	0.542	1,700	4.605	3,200	8.667	4,700	12.730	6,200	16.793	7,700	20.856	9,200	24.919
300	0.813	1,800	4.875	3,300	8.938	4,800	13.001	6,300	17.064	7,800	21.127	9,300	25.190
400	1.083	1,900	5.146	3,400	9.209	4,900	13.272	6,400	17.335	7,900	21.398	9,400	25.460
500	1.354	2,000	5.417	3,500	9.480	5,000	13.543	6,500	17.606	8,000	21.668	9,500	25.731
600	1.625	2,100	5.688	3,600	9.751	5,100	13.814	6,600	17.876	8,100	21.939	9,600	26.002
700	1.896	2,200	5.959	3,700	10.022	5,200	14.085	6,700	18.147	8,200	22.210	9,700	26.273
800	2.167	2,300	6.230	3,800	10.293	5,300	14.355	6,800	18.418	8,300	22.481	9,800	26.544
900	2.438	2,400	6.501	3,900	10.563	5,400	14.626	6,900	18.689	8,400	22.752	9,900	26.815
1,000	2.709	2,500	6.771	4,000	10.834	5,500	14.897	7,000	18.960	8,500	23.023	10,000	27.086
1,100	2.979	2,600	7.042	4,100	11.105	5,600	15.168	7,100	19.231	8,600	23.294		
1,200	3.250	2,700	7.313	4,200	11.376	5,700	15.439	7,200	19.502	8,700	23.564		
1,300	3.521	2,800	7.584	4,300	11.647	5,800	15.710	7,300	19.772	8,800	23.835		
1,400	3.792	2,900	7.855	4,400	11.918	5,900	15.980	7,400	20.043	8,900	24.106		
1,500	4.063	3,000	8.126	4,500	12.189	6,000	16.251	7,500	20.314	9,000	24.377		

Example: Find the number of sound seconds corresponding to 4,485.4 yards.

4,400.0 yards = 11.918 sound seconds

85.0 yards = 0.230 sound seconds

0.4 yards = 0.001 sound seconds

4,485.4 yards = 12.149 sound seconds

Table II. Conversion of Sound Seconds to Yards

(Before the distance which sound travels in a given time under other than standard atmospheric conditions can be determined, the time interval must first be corrected to standard conditions.)

Yards	Sound seconds	Yards	Sound seconds	Yards	Sound seconds	Yards	Sound seconds	Yards	Sound seconds	Yards	Sound seconds	Yards	Sound seconds
0.1	36.9	1.6	590.7	3.1	1,144.5	4.6	1,698.3	6.1	2,252.1	7.6	2,805.9	9.1	3,359.7
0.2	73.8	1.7	627.6	3.2	1,181.4	4.7	1,735.2	6.2	2,289.0	7.7	2,842.8	9.2	3,396.6
0.3	110.8	1.8	664.6	3.3	1,218.4	4.8	1,772.2	6.3	2,326.0	7.8	2,879.8	9.3	3,433.6
0.4	147.7	1.9	701.5	3.4	1,255.3	4.9	1,809.1	6.4	2,362.9	7.9	2,916.7	9.4	3,470.5
0.5	184.6	2.0	738.4	3.5	1,292.2	5.0	1,846.0	6.5	2,399.8	8.0	2,953.6	9.5	3,507.4
0.6	221.5	2.1	775.3	3.6	1,329.1	5.1	1,882.9	6.6	2,436.7	8.1	2,990.5	9.6	3,544.3
0.7	258.4	2.2	812.2	3.7	1,366.0	5.2	1,919.8	6.7	2,473.6	8.2	3,027.4	9.7	3,581.2
0.8	295.4	2.3	849.2	3.8	1,403.0	5.3	1,956.8	6.8	2,510.6	8.3	3,064.4	9.8	3,618.2
0.9	332.3	2.4	886.1	3.9	1,439.9	5.4	1,993.7	6.9	2,547.5	8.4	3,101.3	9.9	3,655.1
1.0	369.2	2.5	923.0	4.0	1,467.8	5.5	2,030.6	7.0	2,584.4	8.5	3,138.2	10.0	3,692.0
1.1	406.1	2.6	959.9	4.1	1,513.7	5.6	2,067.5	7.1	2,621.3	8.6	3,175.1		
1.2	443.0	2.7	996.8	4.2	1,550.6	5.7	2,104.4	7.2	2,658.2	8.7	3,212.0		
1.3	480.0	2.8	1,033.8	4.3	1,587.6	5.8	2,141.4	7.3	2,695.2	8.8	3,249.0		
1.4	516.9	2.9	1,070.7	4.4	1,624.5	5.9	2,178.3	7.4	2,732.1	8.9	3,285.9		
1.5	553.8	3.0	1,107.6	4.5	1,661.4	6.0	2,215.2	7.5	2,769.0	9.0	3,322.8		

Example: Find the distance in yards corresponding to 12.149 sound seconds.

10.0 sound seconds = 3,692.0 yards

2.1 sound seconds = 775.3 yards

0.049 sound seconds = 18.1 yards

12.149 sound seconds = 4,485.4 yards

Table III. Conversion of Meters to Sound Seconds

Meters	Sound seconds	Meters	Sound seconds	Meters	Sound seconds	Meters	Sound seconds	Meters	Sound seconds	Meters	Sound seconds	Meters	Sound seconds
100	0.296	1,600	4.739	3,100	9.183	4,600	13.626	6,100	18.069	7,600	22.512	9,100	26.955
200	0.592	1,700	5.036	3,200	9.479	4,700	13.922	6,200	18.365	7,700	22.808	9,200	27.251
300	0.889	1,800	5.332	3,300	9.775	4,800	14.218	6,300	18.661	7,800	23.104	9,300	27.548
400	1.185	1,900	5.628	3,400	10.071	4,900	14.514	6,400	18.958	7,900	23.401	9,400	27.844
500	1.481	2,000	5.924	3,500	10.367	5,000	14.811	6,500	19.254	8,000	23.697	9,500	28.140
600	1.777	2,100	6.220	3,600	10.664	5,100	15.107	6,600	19.550	8,100	23.993	9,600	28.436
700	2.073	2,200	6.517	3,700	10.960	5,200	15.403	6,700	19.846	8,200	24.289	9,700	28.732
800	2.370	2,300	6.813	3,800	11.256	5,300	15.699	6,800	20.142	8,300	24.586	9,800	29.029
900	2.666	2,400	7.109	3,900	11.552	5,400	15.995	6,900	20.439	8,400	24.882	9,900	29.325
1,000	2.962	2,500	7.405	4,000	11.848	5,500	16.292	7,000	20.735	8,500	25.178	10,000	29.621
1,100	3.258	2,600	7.701	4,100	12.145	5,600	16.588	7,100	21.031	8,600	25.474		
1,200	3.555	2,700	7.998	4,200	12.441	5,700	16.884	7,200	21.327	8,700	25.770		
1,300	3.851	2,800	8.294	4,300	12.737	5,800	17.180	7,300	21.623	8,800	26.067		
1,400	4.147	2,900	8.590	4,400	13.033	5,900	17.476	7,400	21.920	8,900	26.363		
1,500	4.443	3,000	8.886	4,500	13.329	6,000	17.773	7,500	22.216	9,000	26.659		

Example: Find the number of sound seconds corresponding to 4,101.5 meters.

4,100.0 meters = 12.145 sound seconds

01.0 meters = 0.003 sound seconds

0.5 meters = 0.001 sound seconds

4,101.5 meters = 12.149 sound seconds

Table IV. Conversion of Sound Seconds to Meters

(Before the distance which sound travels in a given time under other than standard atmospheric conditions can be determined, the time interval must first be corrected to standard conditions.)

Meters	Sound seconds	Meters	Sound seconds	Meters	Sound seconds	Meters	Sound seconds	Meters	Sound seconds	Meters	Sound seconds	Meters	Sound seconds
0.1	33.8	1.6	540.2	3.1	1,046.6	4.6	1,552.9	6.1	2,059.3	7.6	2,565.7	9.1	3,072.1
0.2	67.5	1.7	573.9	3.2	1,080.3	4.7	1,586.7	6.2	2,093.1	7.7	2,599.5	9.2	3,105.9
0.3	101.3	1.8	607.7	3.3	1,114.1	4.8	1,620.5	6.3	2,126.9	7.8	2,633.3	9.3	3,139.7
0.4	135.0	1.9	641.4	3.4	1,147.8	4.9	1,654.2	6.4	2,160.6	7.9	2,667.0	9.4	3,173.4
0.5	168.8	2.0	675.2	3.5	1,181.6	5.0	1,688.0	6.5	2,194.4	8.0	2,700.8	9.5	3,207.2
0.6	202.6	2.1	709.0	3.6	1,215.3	5.1	1,721.7	6.6	2,228.1	8.1	2,734.5	9.6	3,240.9
0.7	236.3	2.2	742.7	3.7	1,249.1	5.2	1,755.5	6.7	2,261.9	8.2	2,768.3	9.7	3,274.7
0.8	270.1	2.3	776.5	3.8	1,282.9	5.3	1,789.3	6.8	2,295.7	8.3	2,802.1	9.8	3,308.5
0.9	303.8	2.4	810.2	3.9	1,316.6	5.4	1,823.0	6.9	2,329.4	8.4	2,835.8	9.9	3,342.2
1.0	337.6	2.5	844.0	4.0	1,350.4	5.5	1,856.8	7.0	2,363.2	8.5	2,869.6	10.0	3,376.0
1.1	371.4	2.6	877.8	4.1	1,384.1	5.6	1,890.5	7.1	2,396.9	8.6	2,903.3		
1.2	405.1	2.7	911.5	4.2	1,417.9	5.7	1,924.3	7.2	2,430.7	8.7	2,937.1		
1.3	438.9	2.8	945.3	4.3	1,451.7	5.8	1,958.1	7.3	2,464.5	8.8	2,970.9		
1.4	472.6	2.9	979.0	4.4	1,485.4	5.9	1,991.8	7.4	2,498.2	8.9	3,004.6		
1.5	506.4	3.0	1,012.8	4.5	1,519.2	6.0	2,025.6	7.5	2,532.0	9.0	3,038.4		

Example: Find the distance in meters corresponding to 12.149 sound seconds.

10.0 sound seconds = 3,376.0 meters

2.1 sound seconds = 709.0 meters

0.049 sound seconds = 16.5 meters

12.149 sound seconds = 4,101.5 meters

Table V. Temperature-Time Conversion

$$\frac{\text{conversion number}}{\text{length of subbase in meters}} = \text{factor}$$

Factor x time interval = time interval converted to 4-second equivalent, temperature-corrected.

Temp °F.	Conversion No.	Temp °F.	Conversion No.	Temp °F.	Conversion No.	Temp °F.	Conversion No.	Temp °F.	Conversion No.	Temp °F.	Conversion No.	Temp °F.	Conversion No.
-70	1180.9	-35	1232.7	1	1283.9	31	1325.0	61	1364.9	91	1403.6	116	1435.1
-69	1182.4	-34	1234.2	2	1285.3	32	1326.4	62	1366.2	92	1404.9	117	1436.4
-68	1183.9	-33	1235.6	3	1286.7	33	1327.7	63	1367.5	93	1406.2	118	1437.6
-67	1185.4	-32	1237.1	4	1288.1	34	1329.0	64	1368.8	94	1407.4	119	1438.9
-66	1186.9	-31	1238.5	5	1289.4	35	1330.4	65	1370.1	95	1408.7	120	1440.1
-65	1188.4	-30	1240.0	6	1290.8	36	1331.7	66	1371.4	96	1410.0	121	1441.3
-64	1189.9	-29	1241.4	7	1292.2	37	1333.1	67	1372.7	97	1411.3	122	1442.6
-63	1191.4	-28	1242.9	8	1293.6	38	1334.4	68	1374.0	98	1412.5	123	1443.8
-62	1192.9	-27	1244.3	9	1295.0	39	1335.8	69	1375.3	99	1413.8	124	1445.1
-61	1194.4	-26	1245.7	10	1296.4	40	1337.1	70	1376.6	100	1415.0	125	1446.3
-60	1195.9	-25	1247.2	11	1297.7	41	1338.4	71	1377.9	101	1416.3	126	1447.5
-59	1197.4	-24	1248.6	12	1299.1	42	1339.8	72	1379.2	102	1417.6	127	1448.8
-58	1198.9	-23	1250.0	13	1300.5	43	1341.1	73	1380.5	103	1418.8	128	1450.0
-57	1200.4	-22	1251.5	14	1301.9	44	1342.4	74	1381.8	104	1420.1	129	1451.2
-56	1201.9	-21	1252.9	15	1303.2	45	1343.8	75	1383.1	105	1421.4	130	1452.5
-55	1203.4	-20	1254.3	16	1304.6	46	1345.1	76	1384.4	106	1422.6	131	1453.7
-54	1204.9	-19	1255.7	17	1306.0	47	1346.4	77	1385.7	107	1423.9	132	1454.9
-53	1206.4	-18	1257.2	18	1307.3	48	1347.7	78	1387.0	108	1425.1	133	1456.1
-52	1207.8	-17	1258.6	19	1308.7	49	1349.1	79	1388.3	109	1426.4	134	1457.4
-51	1209.3	-16	1260.0	20	1310.1	50	1350.4	80	1389.5	110	1427.6	135	1458.6
-50	1210.8	-15	1261.4	21	1311.4	51	1351.7	81	1390.8	111	1428.9	136	1459.8
-49	1212.3	-14	1262.8	22	1312.8	52	1353.0	82	1392.1	112	1430.1	137	1461.0
-48	1213.7	-13	1264.2	23	1314.2	53	1354.4	83	1393.4	113	1431.4	138	1462.3
-47	1215.2	-12	1265.7	24	1315.5	54	1355.7	84	1394.7	114	1432.6	139	1463.5
-46	1216.7	-11	1267.1	25	1316.9	55	1357.0	85	1396.0	115	1433.9	140	1464.7
-45	1218.2	-10	1268.5	26	1318.2	56	1358.3	86	1397.2				
-44	1219.6	-9	1269.9	27	1319.6	57	1359.6	87	1398.5				
-43	1221.1	-8	1271.3	28	1321.0	58	1360.9	88	1399.8				
-42	1222.5	-7	1272.7	29	1322.3	59	1362.3	89	1401.1				
-41	1224.0	-6	1274.1	30	1323.7	60	1363.6	90	1402.4				
-40	1225.5	-5	1275.5										
-39	1226.9	-4	1276.9										
-38	1228.4	-3	1278.3										
-37	1229.8	-2	1279.7										
-36	1231.3	-1	1281.1										
		0	1282.5										

APPENDIX III

CORRECTIONS FOR CURVATURE AND REFRACTION USED IN FLASH RANGING

Table VI. Curvature and Refraction

(The corrections in the table are always added to the height of the point as determined from the vertical angle from a station of known height.)

Range (meters or yards)	Correction (meters or yards)	Range (meters or yards)	Correction (meters or yards)
1,000	0.1	16,000	15.8
2,000	0.2	17,000	17.8
3,000	0.6	18,000	19.9
4,000	1.0	19,000	22.2
5,000	1.5	20,000	24.6
6,000	2.2	21,000	27.1
7,000	3.0	22,000	29.8
8,000	3.9	23,000	32.6
9,000	5.0	24,000	35.5
10,000	6.2	25,000	38.5
11,000	7.4	26,000	41.6
12,000	8.9	27,000	44.9
13,000	10.4	28,000	48.3
14,000	12.1	29,000	51.8
15,000	13.9	30,000	55.4

Correction is read in the same unit of measure with which table is entered. For example, the correction for 6,000 *meters* is 2.2 *meters*; for 6,000 *yards*, the correction is 2.2 *yards*.

APPENDIX IV

VELOCITY OF SOUND IN AIR

The velocity of sound in air for a specific temperature may be determined from the formula—

$$V_x = 337.6 \sqrt{\frac{X + 459.7}{509.7}} \text{ meters per second}$$

Where X equals effective temperature in degrees Fahrenheit, provided by either sound platoon personnel or by the meteorological section of field artillery target acquisition battalion (para. 82b), it includes the effects of both temperature and humidity.

APPENDIX V

SURVEY AND COMPUTATION TABLES FOR CURVED BASES

Table VII. Computation Tables for Curved Bases

Ratio of S to R ¹	Offset angle	Double offset angle	L factor ²	Log L factor ³
1:6.0	169.38m	338.76m	4.8628	0.6868865
1:6.5	156.39m	312.78m	4.8828	0.6886696
1:7.0	145.26m	290.52m	4.8989	0.6900975
1:7.5	135.60m	271.20m	4.9118	0.6912441
1:8.0	127.16m	254.32m	4.9224	0.6921773
1:8.5	119.70m	239.40m	4.9312	0.6929528
1:9.0	113.07m	226.14m	4.9386	0.6936054

¹ Ratio of S to R is ratio of subbase length to radius of base.

² L factor multiplied by subbase length in meters gives length of the long chord (distance M₁ to M₆) in meters.

³ Log L factor plus log subbase length equals log of long chord.

APPENDIX VI

APPEARANCE OF OBJECTS AT DIFFERENT DISTANCES

1. Near Appearance

An object appears nearer when—

- a. One is looking over water or over a large ravine or depression.
- b. The sun is behind the observer.
- c. The air is clear, especially after a rain.
- d. The color of the background is in contrast with the color of the object.
- e. One is using field glasses.
- f. Trees are leafless, as in winter.
- g. Trees or branches are silhouetted against a clear skyline or contrasting background.

2. Distant Appearance

An object appears more distant when—

- a. One is looking over rolling country.
- b. The sun is in front of the observer.
- c. The air is not clear owing to fog, smoke, rain, etc.
- d. The background is similar in color to that of an object.
- e. One is observing from a kneeling or sitting position on hot days, especially when the ground is moist (owing to heat radiation).

3. Appearance of Objects at Different Ranges

When field glasses are used, the appearance of objects is different at different ranges (in meters) as indicated below.

Range in meters	Trees	Troops	Buildings
1,000	Minor branches distinguishable; foliage thinly clustered, with sky as background; daylight can be seen through the branches.		
1,200		Infantry column distinguishable.	Signposts and national insignias distinguishable.
1,500	Foliage densely clustered, presenting a rough surface: outlines of large branches or group of branches distinguishable.	Small masses of dismounted troops distinguishable; mounted troops and outline of horses distinguishable; vehicles in column distinguishable.	
3,000	Lower half of trunks visible; main branches blend with foliage.	Truck columns and horse-drawn artillery distinguishable.	
4,000	Trunks blend with foliage; surface of clusters smooth.		Ordinary houses distinguishable.
5,000	An area covered entirely with trees has appearance of a bushy area seen with naked eye at about 100 yards except that surface is smoother and blacker.		Ordinary factory chimneys and steel water towers distinguishable.
15,000			Churches, castles, and prominent buildings distinguishable.

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